SCIENCE

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FRIDAY, OCTOBER 19, 1900.

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PROCEEDINGS OF THE SECTION OF BOTANY AT THE NEW YORK MEETING OF THE AMERICAN ASSOCIATION.

VICE-PRESIDENT TRELEASE'S address on 'Some Twentieth Century Problems' was given in the large botanic laboratory in Schermerhorn Hall, on Monday, June 25th, at 3 p. m. (Published in SCIENCE, 12: 48, 1900.) On the following day and on the 29th, regular sessions were held for the reading of papers after the customary manner, and a list with some abstracts is given below.

The Torrey Botanical Club gave, by invitation, a special memorial program in honor of Dr. John Torrey, in the Museum of the New York Botanical Garden, on Wednesday, June 27th. The principal features of the day were:

'Reminiscences of Dr. Torrey': DR. T. C. PORTER.

'Work of Dr. Torrey as a botanist': DR. N. L BRITTON.

'Historical sketch of the development of botany in New York City': DR. T. F. ALLEN.

'Comment on the earlier botanical history of New York': JUDGE ADDISON BROWN.

'Work of the Torrey Botanical Club': SECRETARY E. S. BURGESS.

Comments and reminiscences: PROFESSOR PECK, PROFESSOR MACLOSKIE, PROFESSOR BEAL and DR. T. F. ALLEN. A communication from JAS. HYATT was also read. These papers will be published in the *Bulletin of the Torrey Botanical Club.*

The sectional committee had concluded arrangements with the Council of the Botanical Society of America by which the pro-

gram of the latter occupied the sessions on Thursday. A symposium on the plant geography of North America had been arranged for Friday, June 29th, in which the following papers were read:

'Distribution of the Spermatophytes in New England': B. L. Robinson.

'Distribution of the Spermatophyta in Southeastern United States': J. K. Small.

'Notes on the Lower Austral Element in the Flora of the southern Appalachian region': Thos. Kearney.

'Physiographic Ecology of Northern Michigan': H. C. Cowles.

'Vegetative Elements of the Sandhill region': Roscoe Pound.

'Composition of the Rocky Mountain Flora': Per Axel Rydberg.

'Flora of the Columbian Lavas': C. V. Piper.

'Distribution of the Grasses of North America': G. V. Nash.

'Relationship between the North and South American Floras': W. L. Bray.

'Floral Zones of Mexico': J. N. Rose.

'Origin of the flora of North America': N. L. Britton.

The committee on bibliography reported that the publication of the card catalogue of literature relating to American Botany had been undertaken by the Torrey Botanical Club.

The Bacterial Air-Flora of the Semi-Desert Region of New Mexico: By John Weinzirl.

The study of the air-flora of our semi-desert region possesses considerable interest, especially since no similar investigation has been made under the same conditions. Our climate is characterized by extreme dryness, intense sunlight, hot summers and mild winters, and possesses considerable altitude.* Outside of the river valleys and in the mountain ranges, vegetation is scarce. Because of these facts it is generally supposed that practically no bacterial life exists here. In making this investigation, it was thought that simple petri plate exposures would give results sufficiently accurate for our purpose. Later a number of quantitative determinations were also made, a sand filter and aspirator can being used for this purpose. Regulation petri plates of approximately 3.5 inches internal diameter were used. Agar-agar seemed to be the most suitable medium, since the high colors of the air germs are especially prominent upon it. For comparative purposes, the number of bacteria falling upon the plates were reduced to a basis of 10 min. exposures. The number of plates exposed at one time was usually three, the results being averaged for the final figure. Seventeen exposures were made near the University of New Mexico, which is situated upon an elevated table land or 'mesa' east of Albuquerque. The time covered seven months—September to May. The number of bacteria falling upon the plates during 10 minutes was 35.8. The number fell as low as 3.8 in February, and rose to 71 in September. Thus the falling off in number during the winter season was quite marked. Comparative experiments were also made between the air of the 'mesa' and that of the residence and business districts of Albuquerque, the population of which is about 10,000. For approximate ratios we have 1:6 between mesa and residence district; and 1:80 between mesa and business district. Similar experiments were made to show the difference between the air in the morning and evening for residence and business parts of the city. For the former we have an approximate ratio of 1:4; and for the latter 1:5. It need scarcely be added that the great increase for the evening (6 P. M.) is due to the activities incident to city life. A special test of the altitude factor was made in the latter part of July, 1900, the Sandia Mts. being selected for the experiments. Plates were exposed in the usual way, at approximately 7,000 ft., 8,500 ft. and 10,000 ft.,

* The altitude of Albuquerque is nearly 5,000 feet.

the last number representing the highest peak. A considerable number of bacteria were obtained in each instance, the highest peak giving 18 per plate for 10 minutes. Quantitative determinations were made of the bacteria in mesa air and that of the residence district of Albuquerque. Five determinations (Nov.–Apr.) on the mesa gave an average of 41.6 bacteria per cubic meter or 1,000 liters. The eleven determinations in the city gave 143 bacteria per cubic meter. Both these results are lower than Miquel's figures for Mont-Souris park near Paris in winter, his average for 10 years being 170 per cubic meter. It would seem then, that the air of our semi-desert region is freer from bacteria life than other inhabited regions, but not as free as is popularly believed. The presence of a considerable number of bacteria in the air here, and even on the mountain tops is accounted for mainly by two factors, viz, large quantities of dust and relatively high winds. The extreme dryness facilitates dust formation and the high winds distribute what bacteria may be contained in the dust. As to the flora itself, it has already been noted that chromogenic species are prominent. Six out of fourteen species isolated are chromogens. Four of these are micrococci, viz, A_1 (salmon-pink), A_5 (pink), A_2 (sulphur-yellow) and A_4 (orange). Two are bacilli, A_6 (yellow) and A_{10} (pale-yellow). The remaining colonies are white or gray-white, and with the exception of A_8, all are bacilli. Apparently all the species are new. It is worthy of note that this flora is characteristic for a large area of territory as is shown by experiments made at Belen, Socorro, Magdalena, Magdalena Mts. and the Sandia Mts. previously mentioned. This includes territory more than 100 miles distant from Albuquerque. The wide distribution of this flora is undoubtedly due to the high winds which have a free sweep over the nearly barren mesas.

Field Experiments with Tomato Rot: By F. S. EARLE.

In a paper read before the Botanical Club at the Columbus meeting* it was pointed out that the 'black rot' or 'blossom end rot' of the tomato was caused by an undetermined species of *Bacillus;* and it was suggested that natural infections in the field were probably due to the agency of some small insect. Thrips were suggested as the possible agents of infection since they had frequently been observed in connection with the disease. It was also remarked that there seemed to be more hope in seeking remedies among the insecticides rather than among the fungicides. In order to test these views the following field experiments were carried out during the spring of 1900. It was hoped that some of the insecticides used might also be of benefit in controlling the fall worm. Nine plots were set with approximately 100 plants each. All were fertilized and cultivated alike and all were pruned to a single stem and were topped after setting the third fruit cluster. Plots 1, 8 and 9 were checks. The other plots were sprayed eight times each at intervals of three to five days with kerosene, whale oil soap and 'Rose Leaf' tobacco extract, singly and in combination as is shown by the following table. The kerosene was applied as a 10% mechanical mixture, the soap as a 1½ lb. to 1 gal. of water solution and the 'Rose Leaf' as a 1 pt. to 1 gal. solution. The kerosene proved to burn the foliage injuriously when applied with the other solutions and it was dropped from plots 3 and 6 after the third spraying. The whale oil soap solution also injured the foliage slightly. The plots were gone over every other day and all wormy and rotted fruits were removed and counted. The ripening fruits were also counted when picked and the

*Since published as a part of Ala. Exp. Sta. Bull., No. 109, pp. 20–25.

sound ones remaining on the vines at the close of the experiment.

Plot number.	Treatment, sprayed 8 times at 3 to 5 day intervals.	Total yield of fruits per 100 plants.	Number of rotted fruits per 100 plants.	Per cent. of rot.	Number of wormy fruits per 100 plants.	Per cent. of wormy fruits.
1.	Check.	1366	379	27	187	13
2.	10 per cent. mechanical mixture kerosene and water.	1417	301	21	378	26
3.	10 per cent. kerosene and whale oil soap, 1½ lbs. to 1 gal.	1495	384	25	407	27
4.	Whale oil soap, 1½ lbs. to 1 gal.	1309	243	18	456	39
5.	'Rose Leaf' tobacco extract, 1 pt. to 1 gal.	1467	202	13	443	32
6.	'Rose Leaf' as above and kerosene 10 per cent.	1355	170	12	513	37
7.	'Rose Leaf' as above, and whale oil soap as above.	1518	339	22	584	38
8.	Check.*	1490	188	12	589	39
9.	Check	1241	177	14	526	42

As seen from the above table the number of rotted fruits varied from 12% to 27% in the different plots, the highest being one of the checks and the lowest also one of the checks and the plot receiving 'Rose Leaf' and kerosene. The average for all the plots was 20½%, for the three check plots it was 17⅔%, for the three plots receiving 'Rose Leaf' tobacco extract either alone or in combination, it was only 15⅔%, while for the three whale oil soap plots it rose to 21⅔%. These figures slightly favor the tobacco treatment, but as the average is only 27% less than that of the checks and only 5% less than the average for all the plots, while the different check plots varied among themselves as much as 15%, it seems best to consider the case as not proven. Thrips were almost entirely absent from the tomato plants this year and no other small insect was observed in sufficient numbers to account for the spread of the disease. It must be admitted that the problem of how natural infections occur is still unsolved, and that no remedy has been discovered. It was noted that on some vines nearly or quite all the fruits rotted, while on others in the same plot all remained sound. The high average in plots 1 and 3 was due to the condition of a few plants where all the fruits became diseased and plot 9 would have had a lower average than any but for a few plants in the outside row. It was also noted that dry weather favored the spread of the disease, while a period of daily showers would almost entirely prevent the appearance of new cases. This agrees with previous observations.

The number of wormy fruits varied from 13% in plot 1 to 42% in plot 9. This progressive increase in numbers indicates that in this case the position of the plot in the field rather than the treatment was the controlling factor.

* This plot was intended for Bordeaux mixture and Paris green, but owing to accident to spray pump, only one application was made and that is not believed to have affected the result.

Concentric Spore Spots: By B. D. Halsted.

The spores of parasitic fungi generally reach the surface of the host for aërial distribution by either the hyphæ of the fungus passing out through the stomata and afterwards bearing the spores free in the air, or in forming in masses just beneath the epidermis through which they break and thus become liberated. The peronosporas, cercosporas, ramularias and macrosporiums are good examples of the first named method, while the cystopus and gloeosporium are instances of the second type, which includes the vast number of members of the true rust fungi. In Æcidium and allied genera there is a special organ which envelops the spores, lifts the epidermis and bursts open as a deeply-seated cup. Similar to this is a large number of the *fungi imperfecti* with the septorias and phylostictas as types where the pycnidium makes a way through the epidermis and presents its mouth free for the

discharge of the spores. Those fungi that produce their spores directly upon the surface through the stomata have their area of sporification defined by the distribution of the stomata and the veins and veinlets become boundary lines in many instances. When the fungus has the habit, as in the rusts, of massing the sporiferous hyphæ beneath the epidermis a new set of conditions is introduced. It is found in such, by microscopic examination, that the portion of the host just beneath the rupture is almost entirely replaced by the dense plexus of fungus hyphæ, and the host tissue is destroyed and the immediate threads are not favorably situated for further growth. At a short distance from the sorus in all directions the vitality is probably greater and new points of spore-production are established, resulting in a secondary circle of sori surrounding the original spore-spot. The development of this circle may be followed by a second ring of sori, each sorus more or less crescent-shaped until the host shows 'fairy rings' as real as those in the lawn or meadow and for a similar reason. Plants showing this concentric growth and fruitage of its fungous parasite are numerous. Among those best illustrating the phenomenon are *Cystopus candidus* (P.) upon Bursa, Nasturtium, and several other Cruciferæ; *Puccinia asparagi* DC. upon *Asparagus officinale* L.; *Puccinia Arenaria* (Schum) on *Dianthus barbatus* L.; and *Puccinia Hieracii?* upon *Chrysanthemum Sinense* Sab. All of these were shown by means of microphotographs.

An Anthracnose and a Stem Rot of Antirrhinum majus: By F. C. STEWART.

Antirrhinum majus is subject to two destructive diseases: (1) An anthracnose caused by a new species of *Colletotrichum* for which the author proposes the name *Colletotrichum antirrhini;* (2) A stem rot caused by an undetermined species of *Phoma*.

The *Colletotrichum* is destructive to plants of all ages, at all seasons, both in the greenhouse and in the field. It produces numerous elliptical depressed spots on the stems and circular dead brown spots on the leaves. It fruits sparingly, except in a very moist atmosphere. It has been successfully combated by spraying the plants once a week with Bordeaux mixture. The *Phoma* attacks the stems, causing sections an inch or more in length to turn brown or black. The attack may be made at any point on the stems above ground but is most likely to occur a few inches below the tips of succulent shoots. The portion of the shoot beyond the point of infection quickly wilts and dies. Inoculation experiments with pure cultures of the *Phoma* have shown that it is an active parasite on succulent shoots but attacks woody stems with difficulty.

Notes upon Peltandra rust, Cœomurus Caladii (Schw.) Kunze Abstract: By F. H. BLODGETT.

This rust was very abundant in the æcidial stage about the 15th of May, in a bed of hardy aquatics within the New York Botanical Garden. Some leaves were infested upon nearly every plant in the bed, and upon some, all the leaves were infested. Usually the upper portion of the petiole was most severely attacked. In the worst cases the midrib and its branches, and the petiole nearly to the water would be covered with the æcidia. In such cases the plants suffered severely from a bacterial rot affecting first the stems at those points most rusted, thence spreading, until the stem rotted away. Uredosori were not observed until June 7th; they became gradually more abundant, but at no time were they so virulent or so conspicuous as in the earlier stage. The uredosori were confined in many cases to the blade of the leaf, although occasionally found on the midrib and petiole. The uredospores bear a decided resemblance in

shape, to those of the fern rust *Melampsorella aspidiotus* (Pk.) Mag., upon *Onoclea* and other marsh ferns.

A Mold Isolated from Tan-Bark Liquors: By Katharine L. Golden.

A mold was isolated from tan-bark liquors which were obtained from a tanning factory employing the liming process for unhairing the hides. The mold was present in both fresh, sweet and sour liquors. The mold is pink in color and has a characteristic floury appearance, due to the great number of spores formed. The organism fermented sucrose, dextrose and maltose. In most gelatine it grew profusely, developing a pronounced pink color, whereas in the ordinary meat gelatine the development was scanty and pale. Three distinct enzymes were developed by the action of the mold; a tryptic, a diastatic and a rennet enzyme; all three fairly active. The protoplasm in some of the larger hyphæ was strongly motile, though the hyphæ seemed to be possessed of septa. So far as could be determined by the aid of stains and by salts causing osmotic activity in the mold, the seeming septa are thickened rings on the outside of the filaments. The mold developed, in the various media used, an odor resembling that of tanned hides. No sexual organs were developed. Photo-micrographs and diagrams were used to show the appearance of the mold in the various stages of development.

The Embryo-sac of Peperomia pellucida: By Duncan S. Johnson.

The primary archesporial cell of *P. pellucida* is single and subepidermal. It cuts off a single tapetal cell above and then immediately develops to the embryo-sac. The nucleus of the embryo-sac divides by mitosis to sixteen similar nuclei, distributed about in the peripheral layer of cytoplasm. Two of these nuclei are soon found at the upper end of the sac with a rather larger portion of cytoplasm about each. The larger of these two nuclei with its cytoplasm forms the egg, the wall of which is at first very delicate and indistinct. The other seems to play the part of a synergid, and it also has no distinct wall until a much later stage. Eight of the remaining fourteen peripheral nuclei collect in a compact group, located near the lateral or basal wall of the embryo-sac, or often just below the egg. Before the male and female nuclei fuse these eight nuclei fuse together completely into one large nucleus which from this time behaves like the endosperm nucleus of the ordinary Angiosperm embryo-sac. This nucleus divides before any change is visible in the egg. A cell wall is formed immediately at each division, from the cell plate of the spindle, so that in the ripe seed there are forty or more endosperm cells, completely surrounding the embryo except above. The embryo at this time consists of twenty or more cells and reaches half way to the base of the embryo-sac. The remaining six peripheral nuclei are seen at this stage to be flattened against the wall of the but little enlarged embryo-sac by the endosperm cells and show signs of degeneration. The endosperm cells appear at this time to have protoplasmic contents only, but the whole tissue of the relatively much enlarged nucellus is densely packed with starch. The results here given agree with those recently published by Campbell, for this form up to the sixteen-nucleate stage of the embryo-sac. But he finds two synergidæ and interprets the group of eight nuclei as probably antipodals, which he thinks separate again later. He also apparently interprets as part of the embryo the mass of endosperm cells which finally fill most of the embryo-sac and therefore concludes that there is no endosperm.

A Contribution to a Knowledge of the Organogeny of the Flower and of the Embryology of the Caprifoliaceæ: By Nellie P. Hewins.

A study of the embryology of *Viburnum prunifolium* is interesting because the ovules of two of the locules of the tricarpellary ovary early become aborted, while the single ovule of the remaining locule develops normally. The functional ovule which occupies the largest locule attains the anatropous condition before the abortive ovules, from three to five in number, in each of the smaller locules, begin their development. The abortive ovules never become anatropous because of the mechanical conditions arising from lack of space in the locules, which are soon filled by the developing nucelli. The archesporial cell of the abortive ovules either divides to form two megaspores, each of which by successive divisions forms eight nuclei, or else it forms the embryo-sac directly, which in its completed state contains sixteen nuclei. The nuclei are similar in appearance and fail to become differentiated and arranged according to the usual plan of embryo-sacs. These abortive embryo-sacs persist until after fertilization, when they begin to disintegrate. The archesporial cell of the functional ovules divides to form two megaspores, the lower of which usually enlarges to become the embryo-sac. The polar nuclei fuse before anthesis. The antipodal apparatus, which consists of three large cells, increases in size after the formation of the endosperm nucleus until the differentiation of the egg apparatus, when it begins to disintegrate. The nucellar tissue, small in amount, disappears as the embryo-sac develops. The endosperm nucleus divides rapidly, after fertilization, by free-cell division. A bulky endosperm is soon formed and is surrounded by the integument; integumental cells infringing upon the endosperm constitute, as in certain other gamopetalæ, a tapetum, which does not disintegrate. An accumulation of food near the embryo is to be noted.

On the supposed Polymorphism of Eremosphæra viridis: By G. T. MOORE.

This unicellular alga has been the subject of considerable speculation as to its life history and consequent systematic position. De Bary who first described it, thought it might be a desmid, while De Wildeman believed it was more probably a zygospore than a desmid itself. De Toni suggested that *Eremosphæra* was nothing more than a prothallial condition of some fern, and Chodat, one of the most recent observers of this plant, has made out a remarkable case of polymorphism; finding stages resembling *Palmella*, *Schizochlamya*, *Centrosphæra* and other genera, in addition to the formation of zoospores. The author of the present paper has attempted, by means of pure cultures, to demonstrate the true affinities of the plant and after studies covering several years, comes to the conclusion that *Eremosphæra* has no other method of reproduction than that of simple division, and that it cannot be related to any of the numerous genera it has been supposed to resemble. The paper will be published in full in the *Botanical Gazette*.

Note on Arceüthobiüm: By HERMANN VON SCHRENK.

The speaker described the method of seed distribution of these mistletoes, and the germination of the seed. Some large brooms formed by *Arceüthobium pusillum* on the black spruce were shown, and the occurrence of this species on the red spruce in the southern Adirondacks was reported.

The Origin of the Tannin in Galls: By HENRY KRAEMER.

In presenting some notes on the origin of tannin in galls the author limits his observations to examinations of the common 'ink ball' or 'oak-gall' which is produced on *Quercus coccinea* Wang, and *Q. imbricaria* Michx, probably by *Cynips aciculata* O. S. The galls are nearly globular in shape and

mottled with a yellowish or greenish brown. When they fall from the tree the cell contents (besides the organized contents) are made up largely of starch grains. With the development of the larva certain changes are observed in the cell contents. If the galls are placed in solutions of copper acetate (7 per cent.) and allowed to remain for several weeks or months, there separates in the parenchyma cells of the middle zone yellowish crystals or crystalline masses, which may be lens-shaped, star-shaped or fan-shaped, much resembling the different carbohydrates as hesperidin, inulin, etc., which separate in certain plant cells when specimens are placed in alcohol. They are insoluble in water, alcohol, glycerin or chloral solutions. The appearance, reactions and a comparison with copper gallate crystals lead to the conclusion that they are of this composition. When the winged insect has developed, specimens which have been treated with copper acetate solutions show in the parenchyma cells numerous brownish-red tannin masses to which may be adhering some yellowish-brown crystals of gallic acid. The gallic acid appears to be formed at the expense of the starch in the gall during the chrysalis stage of the insect. With the development of the winged insect this then is changed (by simple condensation of two molecules of gallic acid with the loss of one molecule of water) to tannic acid.

A New Species-Hybrid, Salsify: By B. D. Halsted.

Tragopogon, a rather large genus of the Chicory family has two species in the flora of the United States, namely, *T. porrifolius* cultivated for its roots as the 'oyster plant' and a wild species the *T. pratensis* L. The cultivated species is in many ways very different from the wild form, being larger, but most strikingly in the heads of flowers. The *T. porrifolius* has purple corollas, while the *T. pratensis* has yellow and much smaller flowers. The hybrid obtained under garden culture is a close average between the two plants as to size, style of branching and the like, while the flowers are of a peculiar rose color. Perhaps the most interesting feature of the hybrid plants is their great vigor, they blooming profusely after the parent types are out of season and even dead and gone. The number of seeds produced in each head is small in the hybrids, not more than four usually, and a small fraction of the number in the heads of the parent. The individual seeds, however, in the hybrid are much larger than in the true *porrifolius* the larger of the parents. The hope of getting greater vigor of plant and size of root, with possibly a diminished tendency to disease in the hybrid than now found in the old garden form is fully sustained for the first year. Several photographs were shown of flower, fruit, etc.

The Development of the Ovule in Delphinium exaltatum Ait: By Louise B. Dunn.

The gynœcium of *Delphinium* consists normally of three separate carpels, each bearing two rows of anatropous ovules; the development of the ovule as far as determined was the usual angiosperm type. Some of the earlier stages of the embryo-sac were missed. The archesporial cell is one or two layers below the epidermis of the nucellus. The integuments arise first as two annular thickenings around the nucellus, but as the ovule becomes anatropous the integument appears single. The cells of the embryo-sac divide—until they number eight, and the endosperm nucleus is regularly formed by a fusion of two nuclei, one from each pole. The three gourd-shaped antipodal cells are unusually large before fertilization; as in *Aconitum* and others of the *Ranunculaceæ* they seem active from the appearance of their cytoplasm and the staining of the surrounding cells; mitosis

also occurs in them sometimes. It is probable they have some physiological importance in transferring food from the chalazal portion of ovule to the embryo-sac, especially after fertilization, to the growing endosperm tissue. They persist until the embryo is fully formed and do not elongate (as in *Aconitum*) or multiply, but show no signs of degeneration even in the seed. The embryo is very small with heart-shaped cotyledons, and a hypocotyl about one-tenth their length. The suspensor is short, probably only one cell long. The endosperm tissue fills the entire embryo-sac, and is full of oil. The only interesting feature of the ovule development in *Delphinium* seems to be the added arguments in favor of regarding the antipodals as of present physiological use, and not as mere degenerating evidences of a tendency to produce spores in tetrads, or as a partial and functional homologue of the prothallus.

An Attempted New Method of Producing Zygospores in Rhizopus nigricans: By LOUISE B. DUNN.

The method consisted in cultivating spores of stock material of *Rhizopus* on a solid nutrient substance in test tubes. The stock material was the sporangial form, and usually produced zygospores in about a month when sown on sterilized bread. But on a mixture of Pfeffer's nutrient solution and enough gelatine to make it stiff at room temperature, the zygospores were produced in from 6 to 10 days. Trial cultures were also made in test tubes kept at 10° C. and in Petri dishes at room temperature, using the mixture as above; in Pfeffer's solution without the gelatine and on agar-agar. None of these cultures was successful, as only sporangia were formed.

This rapid production of the zygospores could not always be controlled, averaging three times out of five. Experiments to force zygospore formation in wild *Rhizopus* or *Mucor* have not been successful as yet, but it is hoped that future cultures may determine more definitely whether the results are due to confined space and lack of oxygen, to temperature conditions or to nutrient substance used.

The Composition of Endosperm and Milk of the Cocoanut: By J. E. KIRKWOOD and WILLIAM J. GIES.

The authors supplemented the report of their work previously given before the New York Academy of Sciences (SCIENCE, 11, 12; 951, 1900), by presenting the results of later quantitative analyses: The following figures represent the average general composition of the endosperm: Water, 46%; solids, 54%. Of the latter 98.1% is organic and 1.9% inorganic; 43.4% is fat and 21.9% 'crude fiber.' The fresh endosperm contains 0.75% of nitrogen, which is equivalent to about 4.7% of 'albuminoid.' It is probable, however, that much of the nitrogen found exists in the form of 'extractives.' General analysis of the milk gave the following average data: Water, 95.3%; solids, 4.7%. Of the latter 88.5% is organic; 11.5% inorganic. Three dozen determinations of gross relationships gave the following average weights and percentages:

Weight of whole nut, 610 grams.
Integument, 170 grams = 27.9%.
Endosperm, 333 grams = 54.5%.
Milk, 107 grams = 17.6%.

The volume of the milk averaged 105 c.c.

When Increase in Thickness begins in our Trees: By GEO. T. HASTINGS. Presented by W. W. ROWLEE.

As far as could be ascertained no special attention has been given to the time when increase in thickness takes place in our trees. One finds only such general statements as this.* "The inner portion of any one annual ring . . . is formed in the spring; while the outer portion . . .

* Sachs, 'Physiology of Plants,' 1887, pp. 162.

has arisen towards the conclusion of the period of wood-forming activity." It was found that in the broad-leaved trees examined no increase in thickness took place until the buds had opened and the first leaves expanded; that the first formation of new wood was in the neighborhood of the terminal bud; that the first growth was not continuous around the stem, but of vessels and tracheids in irregular groups; that the growth was continued gradually from the one-year twig to the two- and three-year twigs; and that when the new wood begins to form on five- and six-year twigs the process becomes very rapid, seeming as if at that time growth began simultaneously over the whole tree. Growth usually begins and extends more rapidly on the upper more exposed limbs sometimes a week before any sign of growth can be seen on the lower limbs. In the pine an apparent exception was found, for increase in thickness began on two- and three-year twigs before it began on one-year twigs and before the buds had opened. By the time the buds were well opened the growth had extended from the terminal shoot down the trunk and growth was just beginning on the lower branches. This seems to be due to the leaves remaining on the twig for two or three years. In the hemlock, which holds its leaves for six or seven years, the growth, when examined about the end of May, was greatest on six-year twigs and decreased up to the one-year twigs where the growth was slight. On one of the deciduous Gymnosperms, the bald cypress (*Taxodium distichum*), the conditions seem to be as in the broad-leaved, deciduous trees; no growth in thickness begins till the leaves are expanded, and then it begins at the younger branches and extends back to the older ones.

On the Assimilation of some Organic Substances by Plants: By J. F. Clark.

The Rheotropism of Roots: By F. C. Newcombe.

North American Sordariaceæ: By David Griffiths.

The Development of the Egg and Fertilization of Pinus Strobus: By Margaret C. Ferguson.

Nuclear Division in the Hepaticæ: By B. M. Davis.

The History of the Bulbils of Lysimachia terrestris L.: By D. T. MacDougal.

Observation on Root Hairs: By W. J. Beal.

The root hairs of *Agrostemma Githago* L. and *Lilene notiflora* L. arise in vertical rows of epidermal cells, and those of the former are always extensions of the apical end, while they arise in the middle of cells in other species. Great variations in size and form were found, and septate hairs were seen on Chenopodium hybridum. Root hairs are extremely sensitive to changes of temperature and moisture.

D. T. MacDougal,
Secretary.

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*THE FAITH OF SCIENCE.**

It has been said that each man has one thing to say, and that when he speaks twice he repeats the second time what he said the first. I hope that the saying is not wholly true; and yet I fear that in my case there is a grain of truth in it. I was invited to speak a year ago to the Graduates' Club, and I suspect that I then said much that I am always tempted to say to graduate students. However, as your Dean has, for lack of better available material, invited me to address you at this your first meeting of the year, I must say something; and so I shall take down again the old fiddle, and give you what some of you will recognize as merely a variation upon the old tune.

* An address before the Graduate School of the University of Pennsylvania.

Several times this summer there has come into my mind a passage from an early work by Ernst Renan, in which he impresses one with the fact that it is melancholy to contemplate the bewildering masses of monographs with which the increasing specialization on the part of scholars threatens to flood the world.

Upon returning to the University this fall, and turning over the leaves of the new journals, the new books and the off-prints sent me by various friends and correspondents, I am impressed anew by the thought that, in every field of science, the swelling mass of material is indeed bewildering—I will even say appalling—and that the amount of attention that it is possible for any of us to bestow upon much of it seems a poor repayment to the author for his days and nights of a labor usually but poorly requited in the current coin of the realm. I am not speaking of papers printed for the sake of printing, precipitately created out of nothing at the fiat of a restless desire to keep one's self in evidence—the 'let there be noise,' which results in thunder not preceded by the illuminating flash. I speak of earnest efforts to add a little to the sum of human knowledge—a new historical fact dragged from some obscure and out of the way corner by a man who thinks it not without significance; an odd case of the use of the dative in mediæval Latin; a set of experiments, of perhaps doubtful import, on the borderland which separates psychology from physiology; a description of some rather uninteresting beetle; or an analysis of the argument of some equally uninteresting philosophical writer. Of printing for print's sake, many of you know my opinion. But what shall we say touching the numberless publications over which their authors have spent blood and sweat, and which seem to be read chiefly, if at all, by the ungrateful reviewer? When so few care to listen to the song,

> "What boots it, with incessant care,
> * * * * * * *
> To strictly meditate the thankless Muse?"

I speak to those who expect to devote their lives to science, and who, if they have within them any grain of modesty, will probably sometimes feel inclined to ask themselves seriously whether human life is really enriched in any appreciable degree by the fruit of their labors.

There have been ages in the world's history when such questionings would not so naturally have arisen. The many-sided intellectual curiosity which accompanied the new awakening of the world in the fourteenth and fifteenth centuries, did not find it necessary to enquire whether it 'paid' to establish the text of Cicero or to speculate touching the significance of Plato's Timæus. The greater the number of the intellectual enthusiasms alive at a given epoch, the less the likelihood that such a doubt as I have mentioned should arise in any given field. At every age, it is generally assumed that something or other is of importance, and the judgment of the age supports and incites to activity even the humblest worker in that particular field. Who would to-day think of doubting the value of the invention of a new air-brake, the discovery of a new process for obtaining dye-stuffs, or the devising of a new mechanical contrivance for quieting the baby. But scholars who spend their time upon matters which seem to have no connection with such things as these, are, perhaps naturally, called upon, from time to time, to give an account of their stewardship, and not infrequently have reason to doubt whether their contemporaries view their labors as of any value at all. No one likes to stand alone. He who is doubted comes to doubt himself; and he may even come to work in the half-hearted way natural to one without the enthusiasm which is born of faith.

What can I say to you in the face of

these things? Can I prove that every historical fact which may be discovered will be found to have a directly practical ethical or political significance? Can I show that all psychological experimentation is capital in the hands of the pedagogue? Does the discovery of every new beetle prove a boon to the agriculturist or to any one else? Are all philosophers so inspired that we may assume their words to be of value, whether we understand them or not? Manifestly, I can not prove these things, or show in just what respect human life has been enriched by a multitude of seekers after truth who have, perhaps, really succeeded in adding their modicum to the sum total of our knowledge.

Nor do I stand here with any desire to prove such things. The thought which I wish to bring before you is a very different one. It is that it is in no way incumbent upon you to give such a proof, or to torture yourselves with the idea that you must daily justify your labors by the exhibition of what is often called their practical importance. Science and letters would come to a sorry pass if it were regarded as indecorous for man to look upon the naked truth, and if she were held to be a fit object of contemplation only when bundled up in her working clothes and busied about the hearth or the loom. A too narrow attention to what is commonly called 'the practical' would sap the very foundations of progress; would defeat its own ends by cutting off that light which is our final guarantee of life and growth. Shall we close some of the windows in the house of life because this or that age prefers to have its light filtered through a particular medium? What may be the needs of man, the direction of development of society in the ages to succeed our own? Who can tell what knowledge will be found to be of the profoundest moment to those who come after us? Shall we, in our littleness, shut our eyes on the living miracle about us, except at such times as its light reveals just those objects which seem providentially intended for our particular dinner-pail? Some nonsense has, to be sure, been talked about 'truth for truth's sake'; 'truth,' we are apt to object, 'for the sake of life.' But in the larger faith of science, that faith without which the world could not have been where it now is, there is no truth that may not be of value to life; no truth that is not worthy of our highest endeavor.

Perhaps it will be admitted that truth should be sought in a generous spirit, and that, in the history of the human race, the army of those who have peered curiously into the mysteries of human life and the nature of things has played a part that cannot be overestimated. We have, it seems to me, a right to demand so much, at least, of all intelligent men. But the question remains: What can we say touching the individual value of the numberless units that have tramped wearily in the ranks? That the great captains have accomplished something notable few will deny. They have conquered the fair lands that we now cultivate. But how of the common soldier, whose very name is unknown, except to the few who busy themselves with the dusty records of an almost forgotten past, and love to loiter in the by-ways of curious learning? Has he existed to no purpose? Has he toiled in vain?

Surely not. He has done what he could. He has contributed his little to the enlightenment of the race; and out of his very errors, his perplexed and rather aimless marchings to and fro, there may have come a result he little expected and as little hoped. Only he who knows something of the history of human knowledge knows with what pangs of labor the modern world has been brought to the birth. It is an ancient fable that makes Minerva spring fully armed from the head of Jove. Not thus is knowl-

edge born. Human enlightenment is a thing of small beginnings; it is the outgrowth of the life of the race, not the magical creation of a few master minds. Many hands have labored to rear the great edifice, and he who has carried a single stone, even a small one, has not lived in vain.

"Nevertheless," one may whisper, "What if that stone should turn out to be no stone at all, but a clod of earth, and of no value to the building?" I answer: that is not your affair nor mine. Nature is prodigal of the means by which she attains her ends. We share with men in other walks of life the uncertainty as to the ultimate value of our particular labors. It is plainly necessary that there should be physicians and lawyers, and the rest; yet in view of the ignorance which hems us in, in view of the nearness of our horizon and the impossibility of predicting with certainty the remote consequences of human actions, who can dare to estimate the total accomplishment of this life or that? We are a part of a great whole; we must share in the life of the whole; and those of us who are striving to carry our little grain of truth to the common board must rejoice in the wealth of the community, not grow despondent at the smallness of our contribution.

Let me invite you, then, to enter with joy upon your scientific labors. You can be called to no nobler work, and you must approach it in no doubting spirit. You must be inspired with a reverence for truth, and a faith in its priceless value for human life, that will carry you over periods of doubt and despondency; a faith that will gild with its mellow light the dry dust of your daily labor, and cast a ray into even those darker chambers in the blind walls of which you, with others, are striving to open a passage to the light of heaven.

And if you have this faith it will save you from that scientific intolerance which is not more tolerable than intolerance of other kinds. Do not narrow the meaning of the word 'science.' Let it be a synonym for openness of mind, patience, freedom from prejudice, a willingness to see the beauty and admit the importance of truths of many kinds. Do not undervalue the toil of men who delve in obscure corners of fields far remote from your own. The universe is, after all, but one; there is but one science, in the broadest sense of the word. The vibration of an atom, the unfolding of a flower, the structure of a mollusc, the instinct of a brute, and the reason of a man —what is there that does not call for investigation? If I may study the history and trace the development of a group of plants, why may I not investigate, in the same scientific spirit, not merely a group of languages, but a literature or a philosophy? This truth or that truth must not, in our minds, usurp the name of Truth; and the cause of science is not furthered by an enthusiasm which fails to see how many-sided truth is, and with what different instruments one may do good work in different departments. I lay some emphasis upon this point because, with increasing specialization—the natural result of an increase in human knowledge—there goes a certain danger. We cannot all work in all fields, of course; but if we have the truly scientific spirit, we shall value at its real worth faithful work done in every field. Fortunately for you, your association with each other here at the university will tend to open your eyes to the beauty of towers and pinnacles on the edifice of knowledge, which are taking their shape under other hands than your own.

In the name of my colleagues I bid you welcome to the work of the university; and I wish you a full measure of success.

GEORGE STUART FULLERTON.
UNIVERSITY OF PENNSYLVANIA.

ADDRESS OF THE CHAIRMAN OF THE DEPARTMENT OF ASTRONOMY OF THE BRITISH ASSOCIATION.

It has been decided to form a Department of Astronomy under Section A, and I have been requested to give an address on the occasion. In looking up the records of the British Association to see what position astronomy has occupied, I was delighted to find, in the very first volume, 'A Report on the Progress of Astronomy during the Present Century,' made by the late Sir George Airy, so many years our Astronomer Royal, and at that time Plumian Professor of Astronomy at Cambridge. This report, made at the second meeting of the Association, describes, in a most interesting manner, the progress that was made during the first third of the century, and we can gather from it the state of astronomical matters at that time. The thought naturally occurred to me to give a report, on the same lines, to the end of this century, but a little consideration showed that it was impossible in the limited time at my disposal to give more than a bare outline of the progress made.

At the time this report was written we may say, in a general way, that the astronomy of that day concerned itself with the position of the heavenly bodies only, and, except for the greater precision of observation resulting from better instruments and the larger number of observatories at work, this, the gravitational side of astronomy, remains much as it was in Airy's time.

What has been aptly called the New or Physical Astronomy did not then exist. I propose to briefly compare the state of things then existing with the present state of the science, without dealing very particularly with the various causes operating to produce the change; to allude briefly to the new astronomy; and to speak rather fully about astronomical instruments generally, and of the lines on which it is most probable future developments will be made.

In this report * we find that at the beginning of the century the Greenwich Observatory was the only one in which observations were made on a regular system. The thirty-six stars, selected by Dr. Maskelyne, and the sun and moon were observed on the meridian with great regularity, the planets very rarely and only at particular parts of their orbits; small stars, or stars not included in the thirty-six, were seldom observed.

This state of affairs was no doubt greatly improved at the epoch of the report, but it contrasts strongly with the present work at Greenwich, where 5,000 stars were observed in 1899, in addition to the astrographic, spectroscopic, magnetic, meteorological and other work.

Many observatories, of great importance since, were about that time founded, those at Cambridge, Cape of Good Hope, and Paramatta having just been started. A list is given of the public observatories then existing, with the remark that the author is 'unaware that there is any public observatory in America, though there are,' he says, 'some able observers.'

The progress made since then is truly remarkable. The first public observatory in America was founded about the middle of the century, and now public and private observatories number about 150, while the instrumental equipment is in many cases superior to that of any other country. The prophetic opinion of Airy about American observers has been fully borne out. The discovery of two satellites to Mars by Hall in 1877, of a fifth satellite to Jupiter by Barnard in 1892, and the discovery of Hyperion by Bond, simultaneously with Lassall, in 1848, are notable achievements.

The enormous amount of work turned out by the Harvard Observatory and its

* *Brit. Assoc. Report*, 1831-32, p. 125.

branches in South America, all the photographic and spectroscopic work carried out by many different astronomers, and the new lines of research initiated show an amount of enthusiasm not excelled by any other country. A greater portion of the astronomical work in America has been on the lines of the new astronomy, but the old astronomy has not been at all neglected. In this branch pace has been kept with other countries.

From this report we gather that the mural quadrant at most of the observatories was about to be replaced by the divided circle. Troughton had perfected a method of dividing circles, which, as the author says, 'may be considered as the greatest improvement ever made in the art of instrument making.'

Two refractors of 11 and 12 inches aperture had just been imported into this country; clockwork for driving had been applied to the Dorpat and Paris equatorials, but the author had not seen either in a state of action.

The method of mounting instruments adopted by the Germans was rather severely criticised by the author, the general principle of their mounting being 'telescopes are always supported at the middle, not at the ends.'

"Every part is, if possible, supported by counterpoises."

"To these principles everything is sacrificed. For instance, in an equatorial the polar axis is to be supported in the middle by a counterpoise. This not only makes the instrument weak (as the axis must be single), but also introduces some inconvenience into the use of it. The telescope is on one side of the axis; on the other side is a counterpoise. Each end of the telescope has a counterpoise. A telescope thus mounted must, I should think, be very liable to tremor. If a person who is no mechanic and who has not used one of these instruments may presume to give an opinion, I should say that the Germans have made no improvement in instruments except in the excellence of workmanship."

I have no doubt that this question had often occupied Airy's mind, for in the Northumberland Equatorial Telescope which he designed shortly after for Cambridge he adopted what has been called the English form of mounting, where the telescope is supported by a pivot at each side, and a long polar axis is supported at each end. This telescope is in working order at the present time at Cambridge.

When he became Astronomer Royal he used the same design for what was for many years the great equatorial at Greenwich, though the wooden uprights forming the polar axis were in the Greenwich telescope replaced by iron. It says much for the excellence of the design and workmanship of this mounting, designed as it was for an object glass of about 13 inches diameter, when we find the present Astronomer Royal, Mr. Christie, has used it to carry a telescope of 28 inches aperture, and that it does this perfectly.

Notwithstanding the greater steadiness of the English form of mounting, the German form has been adopted generally for the mounting of the large refractors recently made.

There is much interesting matter in this report of an historical character.

As I have already said, the new astronomy, as we know it, did not exist, but in a report * on optics, in the same volume, by Sir David Brewster, we find that spectrum analysis was then occupying attention, and the last paragraph of this report is well worth quoting: "But whatever hypothesis be destined to embrace and explain this class of phenomena, the fact which I have mentioned opens an extensive field of inquiry. By the aid of the gaseous

* *Brit. Assoc. Rep.*, 1831–32, p. 308.

absorbent we may study with the minutest accuracy the action of the elements of material bodies in all their variety of combinations, upon definite and easily recognized rays of light, and we may discover curious analogies between their affinities and those which produce the fixed lines in the spectra of the stars. The apparatus, however, which is requisite to carry on such inquiries with success cannot be procured by individuals, and cannot even be used in ordinary apartments. Lenses of large diameter, accurate heliostats, and telescopes of large aperture are absolutely necessary for this purpose ; but with such auxiliaries it would be easy to construct optical combinations, by which the defective rays in the spectra of all the fixed stars down to the *tenth* magnitude might be observed, and by which we might study the effects of the very combustion which lights up the suns of other systems."

Brewster's words are almost prophetic, and it would almost appear as if he unknowingly held the key to the elucidation of the spectrum lines, for it was not until 1859 that Kirchhoff's discovery of the true origin of the dark lines was made.

Fraunhofer was the first to observe the spectra of the planets and the stars, and to notice the different types of stellar spectra. In 1817 he recorded the spectrum of Venus and Sirius, and later, in 1823, he described the spectrum of Mars ; also Castor, Pollux, Capella, Betelgeux, and Procyon.

Fraunhofer, Lamont, Donati, Brewster, Stokes, Gladstone, and others carried on their researches at a time when the principles of spectrum analysis were unknown, but immediately upon Kirchhoff's discovery great interest was awakened.

With spectrum analysis thus established, aided as it was later by the greater development of photography, the new astronomy was firmly established.

The memorable results arrived at by Kirchhoff were no sooner published than they were accepted without dissent. The works of Stokes, Foucault, and Angström at that period were all suggestive of the truth, but do not mark an epoch of discovery.

Astronomical spectroscopy divided itself naturally into two main branches, the one of the sun, the other of the stars, each having its many offshoots. I shall just mention a few points relating to each. The dark lines in the solar spectrum had already been mapped by Fraunhofer, and now it only needed better instruments and the application of laboratory spectra with Kirchhoff's principle to advance this work still further.

Fraunhofer had already pointed out the way in using gratings, and these were further improved by Nobert and Rutherfurd.

Kirchhoff's 'Map of the Solar Spectrum,' published in 1861–62, was the most complete up to that time ; but the scale of reference adopted by him was an arbitrary one, so that it was not long before this was improved upon. Angström published in 1868 his 'Map of the Normal Solar Spectrum,' adopting the natural scale of wave-lengths for reference, and this remained in use until quite recent times.

The increased accuracy in the ruling of gratings by Rutherfurd materially improved the efficiency of the solar spectroscope, but it was not until Professor Rowland's invention of the concave grating that this work gained any decisive impetus. The maps (first published in 1885) and tables (published in the years 1896–98) of the lines of the solar spectrum are now almost universally accepted and adopted as a standard of reference. These tables alone record about 10,000 lines in the spectrum of the sun, which is in marked contrast to the number 7 recorded by Wollaston at the beginning of the century (1802). Good work in the production of maps has also been done in this country by Higgs.

Michelson has also recently invented a new form of spectroscope called the 'Echelon,'* in which a grating with a relatively small number of lines is employed, the dispersion necessary for modern work being obtained by using a high order (say the hundredth) into which most of the light has been concentrated.

Besides lines recorded in the visual and ultra-violet portions of the solar spectrum, maps have been made of the lines in the infra-red, the most important being that of Langley's, published in 1894, prepared by the use of his 'bolometer.' Good work had, however, been done in this direction previously by Becquerel, Lamansky and Abney; the last, indeed, succeeded even in photographing a part of it.

The recording of the Fraunhofer lines in the solar spectrum is not all, however. The application of the spectroscope to the sun has several epoch-marking events attached to it, notably those of proving the solar character of the prominences and corona, the rendering visible of the prominences without the aid of an eclipse by the discovery of Lockyer and Janssen in 1868, the photography of the prominences both round the limb and those projected on the solar disc by the invention of the spectro-heliograph by Hale and Deslandres in 1890.

Success has not yet favored the many attempts to photograph the corona without an eclipse by spectroscopic means; but even now this problem is being attacked by Deslandres with the employment of the calorific rays.

Spectroscopic work on the sun has led to the discovery of many hundreds of dark lines, the counterparts of which it has not yet been possible to produce on the earth.

But besides those unknown substances which reveal their presence by dark lines, there were two others discovered, which showed themselves only by bright lines, the one in the chromosphere, to which the name of Helium was given, and the other in the corona, to which the name of Coronium was applied.

The former was, however, identified terrestrially by Ramsay in 1895, though the latter is still undetermined. The revision of its wave-length, brought about by the observations of the eclipse of 1898, may, however, result in this element being transferred from the unknown to the known in the near future.

The study of stellar spectra was taken up by Huggins, Rutherfurd and Secchi. Rutherfurd* published in 1862 his results upon a number of stars, and suggested a rough classification of the white and yellow stars; but Secchi deserves the high credit of introducing the first systematic system of differentiation of the stars according to their spectra, he having begun a spectroscopic survey of the heavens for the purpose of classification,† whilst Huggins devoted himself to the thorough analysis of the spectra of a few stars.

The introduction of photography marks another epoch in the study of stellar spectra. Sir William Huggins applied photography as early as 1863,‡ and secured an impression of the spectrum of Sirius, but nearly another decade elapsed before Professor H. Draper § took a photograph of the spectrum of Vega in 1872, which was the first to record any lines. With the introduction of dry plates this branch of the new astronomy received another impetus, and the catalogues of stellar spectra have now become numerous. Among them may be mentioned those of Harvard College, Potsdam, Lockyer, McClean, and Huggins. The 'Draper Catalogue' || of the Harvard College, which is a

* *Ast. Phys. Journ.*, Vol. VIII., 1898, p. 37.

* *Am. Journ.*, Vol. XXXV., 1862, p. 77.

† *ComptesRendus*, T. LVII., 1853.

‡ *Phil. Trans.*, 1864, p. 428.

§ *Am. Journ. of Sc. and Arts*, Vol. XVIII., 1879, p. 421.

|| *Annals Harvard Coll.*, Vol. XXVII., 1890.

spectroscopic Durchmusterung, alone contains the spectra of 10,351 stars down to the 7–8 magnitudes, and this has further been extended by work at Arequipa, whilst Vogel and Müller, of Potsdam,* made a spectroscopic survey of the stars down to 7.5 magnitude between $-1°$ and $+20°$ declination. This has again been supplemented by Scheiner† ('Untersuchungen über die Spectra helleren Sterne'), and by Vogel and Wilsing‡ ('Untersuchungen über die Spectra von 528 Sternen'). Lockyer § in 1892 published a series of large-scale photographs of the larger stars, and more recently McClean || has completed a spectroscopic survey of the stars of both hemispheres down to the $3\frac{1}{2}$ magnitude. For the study and investigation of special types of stars, the researches of Dunér on the red stars made at Upsala, and those of Keeler and Campbell on the bright line stars made at the Lick Observatory, deserve mention. For the study of stellar spectra the use of prisms in slit or objective prism spectroscopes has predominated, though more recently the use of specially ruled gratings has been attended by some degree of success at the Yerkes Observatory.

Several new stars have also been discovered by their spectra by Pickering in his routine work of charting the spectra of the stars in different portions of the sky. The photographic plate containing their peculiar spectra was, however, not examined in many cases until the star had died down again.

Spectrum analysis also opened up another field of inquiry, viz, that of the motion of the stars in the line of sight, based on the process of reasoning due to Doppler, and accordingly named Doppler's Principle.*

The observatories of Greenwich and Potsdam were among the first to apply this to the stars, and more recently Campbell at Lick, Newall at Cambridge, and Belopolsky at Pulkowa have made use of the same principle with enormous success.

It was also discovered that there are certain classes of stars having a large component velocity in the line of sight, which changes its direction from time to time, and in many such cases orbital motion has been proven, as in the case of Algol.

Another case of binary stars has also been discovered spectroscopically and explained by Doppler's principle. I refer to the stars known as spectroscopic binaries, in which the spectrum lines of one luminous source reciprocate over those from the other source of light, according as one is moving towards or away from the earth. This displacement of the spectrum lines led to the discovery of the duplicity of β Aurigæ, and ζ Ursæ Majoris by Pickering.†

Several other such stars have now been detected, notably β Lyræ, and lastly Capella discovered independently by Campbell ‡ at Lick, and Newall § at Cambridge.

The progress of the new astronomy is so closely bound up with that of photography that I shall briefly call to mind some of the many achievements in which photography has aided the astronomer.

Daguerre's invention in 1839 was almost immediately tried with the sun and moon, J. W. Draper and the two Bonds in America, Warren de la Rue in this country, and Foucault and Fizeau in France, being among the pioneers of celestial photog-

* *Astro-Phys. Obs. zu Potsdam*, Vol. III., 1882–83.
† Ibid., Vol. VII., 1895.
‡ Ibid., Vol. XII., 1899.
§ *Phil. Trans.*, Vol. CLXXXIV., A, 1893.
|| *Phil. Trans.*, Vol. CXCI., A, 1898.

* 'Ueber das farbige Licht der Doppelsterne,' . . . *Abhandl. der K. Böhmischen Ges. d. Wiss.* V. Folge, 2. Bd. 1843.
† *Am. Jour.* (3), 39, p. 46 (1890).
‡ *Astro-Phys. Jour.*, Vol. X., p. 177.
§ *Monthly Notices*, Vol. LX., p. 2 (1899).

raphy; but no real progress seems to have been made until after the introduction of the collodion process. Sir John Herschel in 1847 suggested the daily self-registration of the sun-spots to supersede drawings; and in 1857 the de la Rue photo-heliograph was installed at Kew. From 1858–72 a daily record was maintained by the Kew photo-heliograph, when the work was discontinued. Since 1873 the Kew series has been continued at Greenwich, which is supplemented by pictures from Dehra Dûn in India and from Mauritius. The standard size of the sun's disc on these photographs has now been for many years 8 inches, though for some time a 12-inch series was kept up.

The first recorded endeavor to employ photography for eclipse work dates back to 1851, when Berowsky obtained a daguerreotype of the solar prominences during the total eclipse. From that date nearly every total eclipse of the sun has been studied by the aid of photography.

In 1860 the first regularly planned attack on the problem by means of photography was made, when de la Rue and Secchi successfully photographed the prominences and traces of the corona, but it was not until 1869 that Professor Stephen Alexander obtained the first good photograph of the corona.

In recent years, from 1893 up to the total eclipse which occurred last May, photography has been employed to secure large-scale pictures of the corona. These were inaugurated in 1893 by Professor Schaeberle, who secured a 4-inch picture of the eclipsed sun in Chili; these have been exceeded by Professor Langley, who obtained a 15-inch picture of the corona in North Carolina during the eclipse of May, 1900.

Photography also supplied the key to the question of the prominences and corona being solar appendages, for pictures of the eclipsed sun taken in Spain in 1860 terminated this dispute with regard to the prominences, and finally to the corona in 1871.

In 1875, in addition to photographing the corona, attempts were made to photograph its spectrum, and at every eclipse since then the sensitized plate has been used to record both the spectrum of the chromosphere and the corona. The spectrum of the lower layers of the chromosphere was first successfully photographed during the total eclipse of 1896 in Nova Zembla by Mr. Shackleton, though seen by Young as early as 1870, and a new value was given to the wave-length of the coronal line (wrongly mapped by Young in 1869) from photographs taken by Mr. Fowler during the eclipse of 1898 (India).

Lunar photography has occupied the attention of various physicists from time to time, and when Daguerre's process was first enunciated, Arago proposed that the lunar surface should be studied by means of the photographically produced images.

In 1840 Dr. Draper succeeded in impressing a daguerreotype plate with a lunar image by the aid of a 5-inch refractor. The earliest lunar photographs, however, shown in England were due to Professor Bond, of the United States. These he exhibited at the Great Exhibition in 1851. Dancer, the optician, of Manchester, was perhaps the first Englishman who secured lunar images, but they were of small size.*

Another skillful observer was Crookes, who obtained images of 2 inches diameter with an 8-inch refractor of the Liverpool Observatory. In 1852 de la Rue began experimenting in lunar photography. He employed a reflector of some 10 feet focal length and about 13 inches diameter. A very complete account of his methods is given in a paper read before the British Association. Mr. Rutherfurd at a later date having tried an 11½-inch refractor, and also

* Abney (Photography).

a 13-inch reflector, finally constructed a photographic refracting telescope, and produced some of the finest pictures of the moon that were ever taken until recent years. Also Henry Draper's picture of the moon taken September 3, 1863, remained unsurpassed for a quarter of a century.

Admirable photographs of the lunar surface have been published in recent years by the Lick Observatory and others. I myself devoted considerable attention to this subject at one time; but only those surpassing anything before attempted have been published in 1896–99 by MM. Loëwy and Puiseux, taken with the Equatorial Coudé of the Paris Observatory.

Star prints were first secured at Harvard College, under the direction of W. C. Bond, in 1850; and his son, G. P. Bond, made in 1857 a most promising start with double-star measurements on sensitive plates, his subject being the well-known pair in the tail of the Great Bear. The competence of the photographic method to meet the stringent requirements of exact astronomy was still more decisively shown in 1866 by Dr. Gould's determination from his plates of nearly fifty stars in the Pleiades. Their comparison with Bessel's places for the same objects proved that the lapse of a score of years had made no difference in the configuration of that immemorial cluster; and Professor Jacoby's recent measures of Rutherfurd's photographs taken in 1872 and 1874 enforce the same conclusion.

The above facts are so forcible that no wonder that at the Astrophotographic Congress held in Paris in 1887 it was decided to make a photographic survey of the heavens, and now eighteen photographic telescopes of 13 inches aperture are in operation in various parts of world, for the purpose of preparing the international astrographic chart, and it was hoped that the catalogue plates would be completed by 1900.

Photography has been applied so assiduously to the discovery of minor planets that something like 450 are now known, the most noteworthy, perhaps, as regards utility, being the discovery of Eros (433) in 1898 by Herr Witt at the Observatory of Urania, near Berlin.

With regard to the application of photography to recording the form of various nebulæ, it is interesting to quote a passage from Dick's 'Practical Astronomer,' published in 1845, as opposed to Herschel's opinion that the photography of a nebula would never be possible.

"It might, perhaps, be considered as beyond the bounds of probability to expect that even the distant nebulæ might thus be fixed, and a delineation of their objects produced, which shall be capable of being magnified by microscopes. But we ought to consider that the art is only in its infancy, and that plates of a more delicate nature than those hitherto used may yet be prepared, and that other properties of light may yet be discovered which shall facilitate such designs. For we ought now to set no boundaries to the discoveries of science, and to the practical applications of scientific discovery, which genius and art may accomplish."

It was not, however, until 1880 that Draper first photographed the Orion Nebula, and later by three years I succeeded in doing the same thing with an exposure of only thirty-seven minutes. In December, 1885, the brothers Henry by the aid of photography found that the Pleiades were involved in a nebula, part of which, however, had been seen by myself* with my 3-foot reflector in February, 1880, and later, February, 1886, it was also partly discerned at Pulkowa with the 30-inch reflector then newly erected.

* *Monthly Notices*, Vol. XL., p. 376.

Still more nebulosity was shown by Dr. Robert's photographs,* taken with his 20-inch reflector in October and December, 1886, when the whole western side of the group was shown to be involved in a vast nebula, whilst a later photograph taken by MM. Henry early in 1888 showed that practically the whole of the group was a shoal of nebulous matter.

In 1881 Draper and Janssen recorded the comet of that year by photography.

Huggins† succeeded in photographing a part of the spectrum of the same object, (Tebbutt's Comet, 1881, II.) on June 24th, and the Fraunhofer lines were amongst the photographic impressions, thus demonstrating that at least a part of the continuous spectrum is due to reflected sunlight. He also secured a similar result from Comet Wells.‡

I propose to consider the question of the telescope on the following lines: (1) The refractor and reflector from their inception to their present state; (2) The various modifications and improvements that have been made in mounting these instruments, and (3) the instrument that has been lately introduced by a combination of the two, refractor and reflector, a striking example of which exists now at the Paris Exhibition.

At a meeting of the British Association held nearly half a century ago (1852, Belfast) Sir David Brewster showed a plate of rock crystal worked in the form of a lens which had been recently found in Nineveh. Sir David Brewster asserted that this lens had been destined for optical purposes, and that it never was a dress ornament.

That the ancients were acquainted with the powers of a magnifying lens may be inferred from the delicacy and minuteness of the incised work on their seals and intaglios, which could only have been done by an eye aided by a lens of some sort.

There is, however, no direct evidence that the ancients were really acquainted with the refracting telescope, though Aristotle speaks of the tubes through which the ancients observed distant objects, and compares their effect to that of a well from the bottom of which the stars may be seen in daylight.* As an historical fact without any equivocations, however, there is no serious doubt that the telescope was invented in Holland.

The honor of being the originator has been claimed for three men, each of whom has had his partisans. Their names are Metius, Lippershey and Janssen.

Galileo himself says that it was through hearing that some one in France or Holland had made an instrument which magnified distant objects that he was led to inquire how such a result could be obtained.

The first publisher of a result or discovery, supposing such discovery to be honestly his own, ranks as the first inventor, and there is little doubt that Galileo was the first to show the world how to make a telescope.† His first telescope was made whilst on a visit to Venice, and he there exhibited a telescope *magnifying three times;* this was in May, 1609. Later telescopes which emanated from the hands of Galileo magnified successively four, seven and thirty times. This last number he never exceeded.

Greater magnifying power was not attained until Kepler explained the theory and some of the advantages of a telescope made of two convex lenses in his *Catoptrics* (1611). The first person to actually apply this to the telescope was Father Scheiner, who describes it in his *Rosa Ursina* (1630), and Wm. Gascoigne was the first to appreciate practically the chief advantages by

* *Monthly Notices*, Vol. XLVII., p. 24.
† *Proc. Roy. Soc.*, Vol. XXXII., No. 213.
‡ *Rep. Brit. Assoc.*, 1882, p. 442.

* *De Gen. Animalium*, Lib. V.
† Newcomb's *Astronomy*, p. 108.

his invention of the micrometer and application of telescopic sights to instruments of precision.

It was, however, not until about the middle of the seventeenth century that Kepler's telescope came to be nearly universal, and then chiefly because its field of view exceeded that of the Galilean.

The first powerful telescopes were made by Huyghens, and with one of these he discovered Titan (Saturn's brightest satellite): his telescopes magnified from forty-eight to ninety-two times, were about $2\frac{1}{3}$ inches aperture, with focal lengths ranging from 12 to 23 feet. By the aid of these he gave the first explanation of Saturn's ring, which he published in 1659.

Huyghens also states that he made object-glasses of 170 feet and 210 feet focal length; also one 300 feet long, but which magnified only 600 times; he also presented one of 123 feet to the Royal Society of London.

Auzout states that the best telescopes of Campani at Rome magnified 150 times, and were of 17 feet focal length. He himself is said to have made telescopes of from 300 to 600 feet focus, but it is improbable that they were ever put to practical use. Cassini discovered Saturn's fifth satellite (Rhea) in 1672, with a telescope made by Campani, magnifying about 150 times, whilst later, in 1684, he added the third and fourth satellites of the same planet to the list of his discoveries.

Although these telescopes were unwieldy, Bradley, with his usual persistency, actually determined the diameter of Venus in 1722 with a telescope of 212 feet focal length.

With such cumbersome instruments many devices were invented of pointing these *aerial telescopes*, as they were termed, to various parts of the sky. Huyghens contrived some ingenious arrangements for this purpose, and also for adjusting and centering the eyepiece, the object-glass and eyepiece being connected by a long braced rod.

It was not, however, until Dollond's invention of the achromatic object-glass in 1757–58 that the refracting telescope was materially improved, and even then the difficulty of obtaining large blocks of glass free from striæ limited the telescope as regards aperture, for even at the date of Airy's report we have seen that 12 inches was about the maximum aperture for an object-glass.

The work of improving glass dates back to 1784, when Guinand began experimenting with the manufacture of optical flint glass.

He conveyed his secrets to the firm of Fraunhofer and Utzschneider, whom he joined in 1805, and during the period he was there they made the 9.6 inches object-glass for the Dorpat telescope.

Merz and Mädler the successors of Fraunhofer, carried out successfully the methods handed down to them by Guinand and Fraunhofer.

Guinand communicated his secrets to his family before his death in 1823, and they entered into partnership with Bontemps. The latter afterwards joined the firm of Chance Bros., of Birmingham, and so some of Guinand's work came to England.

At the present day MM. Feil, of Paris, who are direct descendants of Guinand and Messrs. Chance Bros., of Birmingham, are the best-known manufacturers of large discs of optical glass.

It is related in history that Ptolemy Euergetes had caused to be erected on a lighthouse at Alexandria a piece of apparatus for discovering vessels a long way off; it has also been maintained that the instrument cited was a concave reflecting mirror, and it is possible to observe with the naked eye images formed by a concave mirror, and that such images are very bright.

Also the Romans were well acquainted with the concentrating power of concave

mirrors, using them as burning mirrors, as they were called. The first application of an eye lens to the image formed by reflection from a concave mirror appears to have been made by Father Zucchi, an Italian Jesuit. His work was published in 1652, though it appears he employed such an instrument as early as 1616. The priority, however, of describing, if not making, a practical reflecting telescope belongs to Gregory, who, in his 'Optica Promota,' 1663, discusses the forms of images of objects produced by mirrors. He was well aware of the failure of all attempts to perfect telescopes by using lenses of various curvature, and proposed the form of reflecting telescope which bears his name.

Newton, however, was the first to construct a reflecting telescope, and with it he could see Jupiter's satellites, etc. Encouraged by this he made another of $6\frac{1}{3}$ inches focal length, which magnified thirty-eight times, and this he presented to the Royal Society on the day of his election to the Society in 1671.

To Newton we owe also the idea of employing pitch, used in the working of the surfaces.

A third form of telescope was invented by Cassegrain in 1672. He substituted a small convex mirror for the concave mirror in Gregory's form, and thus rendered the telescope a little shorter.

Short also, from 1730–68, displayed uncommon ability in the manufacture of reflecting telescopes, and succeeded in giving true parabolic and elliptic figures to his specula, besides obtaining a high degree of polish upon them. In Short's first telescopes the specula were of glass, as suggested by Gregory, but it was not until after Liebig's discovery of the process of depositing a film of metallic silver upon a glass surface from a salt in solution that glass specula became almost universal, and thus replaced the metallic ones of earlier times.

Shortly after the announcement of Liebig's discovery Steinheil*—and later, independently, Foucault†—proposed to employ glass for the specula of telescopes, and, as is well known, this is done in all the large reflectors of to-day.

I now propose to deal with the various steps in the development of the telescope, which have resulted in the three forms that I take as examples of the highest development at the present time. These are the Yerkes telescope at Chicago, my own 5-foot reflector, and the telescope recently erected at the Paris Exhibition, dealing not only with the mountings, but with the principles of construction of each. When the telescope was first used all could be seen by holding it in the hand. As the magnifying power increased some kind of support would become absolutely necessary, and this would take the form of the altitude and azimuth stand, and the motion of the heavenly bodies would doubtless suggest the parallactic or equatorial movement, by which the telescope followed the object by one movement of an axis placed parallel to the pole. This did not come, however, immediately. The long focus telescopes of which I have spoken were sometimes used with a tube, but more often the object-glass was mounted in a long cell and suspended from the top of a pole, at the right height to be in a line between the observer and the object to be looked at; and it was so arranged that by means of a cord it could be brought into a fairly correct position. Notwithstanding the extreme awkwardness of this arrangement most excellent observations were made in the seventeenth century by the users of these telescopes. Then the achromatic telescope was invented and mechanical mountings were used, with circles for finding positions, much as we have them now. I have already mentioned the rivalry

* *Gaz. Univ. d'Augsburg*, March 24, 1856.

† *Comptes Rend.*, Vol. XLIV., February, 1857.

between the English and German forms of mountings, and Airy's preference for the English form. The general feeling amongst astronomers has, however, been largely in favor of the German mounting for refractors, due, no doubt, to a great extent, to the enormous advance in engineering skill. We have many examples of this form of mounting. A list of the principal large refracting and reflecting telescopes now existing is given. All the refractors in this list, with the exception of the Paris telescope of 50 inches and the Greenwich telescope of 28 inches, are mounted on the German form.

List of Large Telescopes in Existence in 1900.

Refractors 15 inches and upwards.	Inches.
Paris (Exhibition)	50
Yerkes	40
Lick	36
Pulkowa	30
Nice	29.9
Paris	28.9
Greenwich	28.0
Vienna	27.0
Washington, U. S.	26.0
Leander, McCormick Observatory, Vir.	26.0
Greenwich	26.0
Newall's, Cambridge	25.0
Cape of Good Hope	24.0
Harvard	24.0
Princeton, N. J., U. S.	23.0
Mount Etna	21.8
Strassburg	19.1
Milan	19.1
(Dearborn) Chicago	18.5
Warner Observatory, Rochester, U. S.	16.0
Washburn Observatory, Madison, Wis.	15.5
Edinburgh	15.1
Brussels	15.1
Madrid	15.0
Rio Janeiro	15.0
Paris	15.0
Sir William Huggins	15.0
Paris	15.0

Reflectors 2 feet 6 inches and upwards.	Ft.	In.
Lord Rosse	6	0
Dr. Common	5	0
Melbourne	4	0
Paris	4	0
Meudon	3	3
South Kensington	3	0
Crossley (Lick)	3	0
Greenwich	2	6
South Kensington	2	6

Some of these carry a reflector as well as, for instance, the telescope lately presented to the Greenwich Observatory by Sir Henry Thompson, which, in addition to a 26-inch refractor, carries a 30-inch reflector at the other end of the declination axis, such as had been previously used by Sir William Huggins and Dr. Roberts; the last, and perhaps the finest, example of the German form being the Yerkes telescope at Chicago.

The small reflector made by Sir Isaac Newton, probably the first ever made, and now at the Royal Society, is mounted on a ball, gripped by two curved pieces attached to the body of the telescope, which allows the telescope to be pointed in any direction. We have not much information as to the mounting of early reflectors. Sir William Herschel mounted his 4-foot telescope on a rough but admirably planned open-work mounting, capable of being turned round and with means to tilt the telescope to any required angle. This form was not very suitable for picking up objects or determining their position, except indirectly; but for the way it was used by Sir William Herschel it was most admirably adapted: the telescope being elevated to the required angle, it was left in that position, and became practically a transit instrument. All the objects passing through the field of view (which was of considerable extent, as the eye-piece could be moved in declination) were observed, and their places in time and declination noted, so that the positions of all these objects in the zone observed were obtained with a considerable degree of accuracy. It was on this plan that Sir John Herschel made his general catalogue of nebulæ, embracing all the nebulæ he could see in both hemispheres; a complete work by one man that is almost unique in the history of astronomy.

Sir William Herschel's mounting of his 4-foot reflector differs in almost every particular from the mountings of the long-

focus telescopes we have just spoken of. The object-glass was at a height, the reflector was close to the ground. There was a tube to one telescope, but not to the other. The observer in one case stood on the ground, in the other he was on a stage at a considerable elevation. One pole sufficed with a cord for one; a whole mass of poles, wheels, pulleys and ropes surrounded the other. In one respect only were they alike —they both did fine work.

Lassell seems to have been the first to mount a reflector equatorially. He, like Herschel, made a 4-foot telescope, and this he mounted in this way. Lord Rosse mounted his telescopes somewhat after the manner of Sir William Herschel. The present earl has mounted a 3-foot equatorially.

A 4-foot telescope was made by Thomas Grubb for Melbourne, and this he mounted on the German plan. The telescope being a Cassegrain, the observer is practically on the ground level. A somewhat similar instrument exists at the Paris Observatory. Lassell's 4-foot was mounted in what is called a fork mounting, as is also my own 5-foot reflector, and this in some ways seems well adapted for reflectors of the Newtonian kind.

We now come to the Paris telescope. This is really the result of the combination of a reflector and a refractor. I cannot say when a plane mirror was first used to direct the light into a telescope for astronomical purposes. It seems first to have been suggested by Hooke, who, at a meeting of the Royal Society, when the difficulty of mounting the long-focus lenses of Huyghens was under discussion, pointed out that all difficulties would be done away with if, instead of giving movement to the huge telescope itself, a plane mirror were made to move in front of it.*

The Earl of Crawford, then Lord Lindsay, used a heliostat to direct the rays from the sun, on the occasion of the transit of Venus, through a lens of 40 feet focal length, in order to obtain photographs, and it was also largely used by the American observers on the same occasion.

Monsieur Loëwy at Paris proposed in 1871 a most ingenious telescope made by a combination of two plane mirrors and an achromatic object-glass, which he calls a Coudé telescope, which has some most important advantages. Chief amongst these that the observer sits in perfect comfort at the upper end of the polar axis, whence he need not move, and by suitable arrangements he can direct the telescope to any part of the visible heavens. Several have been made in France, including a large one of 24 inches aperture, erected at the Paris Observatory, and which has already made its mark by the production of perhaps the best photographs of the moon yet obtained. I have already spoken of Lord Lindsay and his 40-foot telescope, fed, as it were, with light from a heliostat. This is exactly the plan that has been followed in the design of the large telescope in the Paris Exhibition. But in place of a lens of 4 inches aperture and a heliostat a few inches larger, the Paris telescope has a plane mirror of 6 feet and a lens exceeding 4 feet in diameter, with a focal length of 186 feet. The cost of a mounting on the German plan and of a dome to shelter such an instrument would have been enormous. The form chosen is at once the best and cheapest. One of the great disadvantages is that from the nature of things it cannot take in the whole of the heavens. The heliostat form of mounting of the plane mirror causes a rotation of the image in the field of view which in many lines of research is a strong objection. There is much to be said on the other side. The dome is dispensed with, the tube, the equatorial mounting and the rising floor are not wanted. The mechanical arrangements of

* Lockyer, *Star-gazing*, p. 453.

importance are confined to the mounting of the necessary machinery to carry the large plane mirror and move it round at the proper rate. The telescope need not have any tube (that to the Paris telescope is of course only placed there for effect), as the flimsiest covering is enough if it excludes false light falling on the eye end; and more important than all, the observer sits at his ease in the dark chamber. This question of the observer, and the conditions under which he observes, is a most important one as regards both the quality and quantity of the work done.

We have watched the astronomer, first observing from the floor level; then mounted on a high scaffold like Sir William Herschel, Lassell, and Lord Rosse; then, starting again from the floor level and using the early achromatic telescope; then, as these grew in size, climbing up on observing chairs to suit the various positions of the eye end of the telescope, as we see in Mr. Newall's great telescope; then brought to the floor again by that excellent device of Sir Howard Grubb, the rising floor. This is in use with the Lick and the Yerkes telescopes, where the observer is practically always on the floor level, though constant attention is needed, and the circular motion has to be provided for by constant movement, to say nothing of the danger of the floor going wrong. Then we have the ideal condition, as in the Equatorial Coudé at the Paris Observatory, where the observer sits comfortably sheltered and looks down the telescope, and from this position can survey the whole of the visible heavens. The comfort of the observer is a most important matter, especially for the long exposures that are given to photographic plates, as well as for continued visual work. In such a form of telescope as that at Paris the heliostat form of mounting the plane mirror is most suitable, notwithstanding the rotation of the image. But there is another way in which a plane mirror can be mounted, and that is on the plan first proposed by Auguste many years ago, and lately brought forward again by Mons. Lippman, of Paris, and that is by simply mounting the plane mirror on a polar axis and parallel therewith, and causing the mirror to rotate at half the speed of the earth's rotation. Any part of the heavens seen by any person reflected from this mirror will appear to be fixed in space, and not partake of the apparent movement of the earth, so long as the mirror is kept moving at this rate. A telescope, therefore, directed to such a mirror can observe any heavenly body as if it were in an absolutely fixed position, so long as the angle of the mirror shall not be such as to make the reflected beam less than will fill the object-glass. There is one disadvantage in the cœlostat, as this instrument is called, and that is its suitability only for regions near the equator. The range above and below, however, is large enough to include the greater portion of the heavens, and that portion in which the solar system is included. Here the telescope must be moved in azimuth for different portions of the sky, as is fully explained by Professor Turner in Vol. LVI. of the *Monthly Notices* and it therefore becomes necessary to provide for moving the telescope in azimuth from time to time as different zones above or below the equator are observed. No instrument yet devised is suitable for all kinds of work, but this form, notwithstanding its defects, has so many and such important advantages that I think it will obviate the necessity of building any larger refractors on the usual models. The cost of producing a telescope much larger than the Yerkes on that model, in comparison with what could be done on the plan I now advocate, renders it most improbable that further money will be spent in that way. It may be asked: What are the lines of research which could be taken up by a telescope of this construction, and

on what lines should the telescope be built? I will endeavor to answer this. All the work that is usually done by an astronomical telescope, excepting very long-continued observations, can be equally well done by the fixed telescope. But there are some special lines for which this form of research is admirably suited, such as photographs of the moon, which would be possible with a reflecting mirror of, say, 200 feet focal length, giving an image of some 2 feet diameter in a primary focus, or a larger image might be obtained either by a longer focus mirror or by a combination. It might even be worth while to build a special cœlostat for lunar photography, provided with an adjustment to the polar axis and a method of regulating the rate of clock to correct the irregular motion of the moon, and thus obtain absolutely fixed images on the photographic plate.

The advantage of large primary images in photography is now fully recognized. For all other kinds of astronomical photography a fixed telescope is admirably adapted; and so with all spectroscopic investigations, a little consideration will show that the conditions under which these investigations can be pursued are almost ideal. As to the actual form such a construction would take; we can easily imagine it. The large mirror mounted as a cœlostat in the center; circular tracts around this center, on which a fan-shaped house can be traveled round to any azimuth, containing all the necessary apparatus for utilizing the light from the large plane mirror, so as to be easily moved round to the required position in azimuth for observation. In place of a fan-shaped house movable round the plane mirror, a permanent house might encircle the greater portion round the mirror, and in this house the telescope or whatever optical combination is used might be arranged on an open framework, supported on similar rails, so as to run round to any azimuth required. The simplicity of the arrangement and the enormous saving in cost would allow in any well-equipped observatory the use of a special instrument for special work. The French telescope has a mirror about 6 feet in diameter and a lens of about 4 feet. This is a great step in advance over the Yerkes telescope, and it may be some time before the glass for a lens greater than 50 inches diameter will be made, as the difficulty in making optical glass is undoubtedly very great. But with the plane mirror there will be no such difficulty, as 6 feet has already been made; and so with a concave mirror there would be little difficulty in beginning with 6 feet or 7 feet. The way in which the mirror would be used, always hanging in a band, is the most favorable condition for good work, and the absence of motion during the observation, except of course, that of the plane mirror (which could be given by floating the polar axis and suitable mechanical arrangements, a motion of almost perfect regularity).

One extremely important thing in using silver or glass mirrors is the matter of resilvering from time to time. Up to quite recently the silvering of my 5-foot mirror was a long, uncertain, and expensive process. Now we have a method of silvering mirrors that is certain, quick and cheap. This takes away the one great disability from the silver or glass reflecting telescope, as the surface of silver can now be renewed with greater ease and in less time than the lenses of a large refracting telescope could be taken out and cleaned. It may be that we shall revert to speculum metal for our mirrors, or use some other deposited metal on glass; but even as it is we have the silvered glass reflector, which at once allows an enormous advance in power. To do justice to any large telescope it should be erected in a position, as regards climate, where the conditions are as favorable as possible.

The invention of the telescope is to me the most beautiful ever made. Familiarity both in making and in using has only increased my admiration. With the exception of the microphone of the late Professor Hughes, which enabled one to hear otherwise inaudible sounds, sight is the only sense that we have been able to enormously increase in range. The telescope enables one to see distant objects as if they were at, say, one five-thousandth part of their distance, whilst the microscope renders visible objects so small as to be almost incredible. In order to appreciate better what optical aid does for the sense of sight, we can imagine the size of an eye, and therefore of a man, capable of seeing in a natural way what the ordinary eye sees by the aid of a large telescope, and, on the other hand, the size of a man and his eye that could see plainly small objects as we see them under a powerful microscope. The man in the first case would be several miles in height, and in the latter he would not exceed a very small fraction of an inch in height.

Photography also comes in as a further aid to the telescope, as it may possibly be to the microscope. For a certain amount of light is necessary to produce sensation in the eye. If this light is insufficient nothing is seen; but owing to the accumulative effect of light on the photographic plate, photographs can be taken of objects otherwise invisible, as I pointed out years ago; for in photographs I took in 1883 stars were shown on photographic plates that I could not see in the telescope. All photographs, when closely examined, are made up of a certain number of little dots, as it were, in the nature of stippling, and it is a very interesting point to consider the relation of the size and separation of these dots that form the image, and the rods and cones of the reckoner which determines the power of the eye.

Many years ago I tried to determine this question. I first took a photograph of the moon with a telescope of very short focus (as near as I could get it to the focus of the eye itself, which is about half an inch). The resulting photograph measured one two-hundredth of an inch in diameter, and when examined again with a microscope showed a fair amount of detail, in fact, very much as we see the moon with the naked eye; making a picture of the moon by hand, on such a scale that each separate dot of which it was made corresponded with each separate sensitive point of the retina employed when viewing the moon without optical aid, I found, on looking at this picture at the proper distance, that it looked exactly like a real moon. In this case the distance of the dots was constant, making them larger or smaller, forming the light or shade of the picture.

I did not complete these experiments, but as far as I went I thought that there was good reason to believe that we could in this way increase the defining power of the eye. It is a subject well worthy of further consideration.

I know that in this imperfect and necessarily brief address I have been obliged to omit the names of many workers, but I cannot conclude without alluding to the part that the Association has played in fostering and aiding astronomy. A glance through the list of money grants shows that the help has been most liberal. In my youth I recollect the great value that we put on the 'British Association Catalogue of Stars'; we know the help that was given in its early days to the Kew Observatory; and the reports of the Association show the great interest that has always been taken in our work. The formation of a separate Department of Astronomy is, I hope, a pledge that this interest will be continued, to the advantage of our science.

A. A. Common.

THE FOURTH INTERNATIONAL CONGRESS OF PSYCHOLOGY.

THE Congress was held in Paris, in the Palace of Congresses on the Exposition grounds, from the 20th to the 25th of August, 1900. Its president was Professor Ribot, its vice-president Professor Richet, and its indefatigable secretary, on whom rested most of the work of organization, Dr. Pierre Janet. The registered membership numbered over 350, but a large proportion of these were not present. France was of course very fully represented, but the German and English contingents were small, and the American contingent lacked, among others, Professors James and Baldwin, who had expected to attend, but were prevented. Among the visitors present were Ebbinghaus, Külpe and O. Vogt, Ladd and Münsterberg, Sergi and Ferrari, Myers, Flournoy, Demoor, Tschisch, Mlle. Manacéine, and others whose writings are well known.

The Congress was divided into six sections: the physiological and comparative, under the presidency of Ives Delage; the introspective and philosophical, under Séailles; the experimental, under Binet; the pathological, under Magnan; hypnotism and suggestion, under Bernheim; and social psychology, under Tarde. The morning was usually devoted to section meetings, and the afternoon to general sessions.

The presidential address of Ribot was concerned with the progress made in psychology since the Munich Congress. Among the other principal addresses were those of Ebbinghaus, comparing the psychology of the present with that of 100 years ago; of Demoor, on the functions of nerve cells and of the cerebral cortex, as deduced from histological observations; of Sergi, on the treatment of consciousness in modern psychology; of Solokov, on 'colored hearing' considered as a sort of symbolism; of Tarkhanoff, on illusions and hallucinations of frogs.

Vogt aroused an animated discussion by attacking Flechsig's doctrine of association centers, and by denying any psychological value to anatomical studies of the brain.

Mlle. Manacéine presented the results of some experiments concerning the effects of different foods on the disposition of animals. She found dogs to be more tranquil and less quarrelsome on a vegetable diet than on a meat diet. In this connection, Richet reported similar observations of his own, leading to a similar conclusion, except that only *raw* meat differed in its psychic effects from a vegetable diet. On a diet of raw meat the dogs were more quarrelsome, but also more affectionate to their master; all their instincts and passions were sharpened.

Richet presented a remarkable musical prodigy in the person of a little boy who at the age of two and a half years had surprised his parents by spontaneously playing pieces on the piano. Now, after a year of training, he not only uses his tiny hands with considerable 'virtuosity,' but shows a wonderful memory for classical music, a genuine grasp of expression, ability to compose and improvise—in short, the mastery and independence of an artist. A strange fact is that the child can play only on the poor, broken-toned old piano on which he started. Every attempt to substitute a better instrument has led to failure.

Vaschide read a paper summarizing and adding to the evidence for the independence of the muscular and cutaneous senses. Cutting the cutaneous nerves does not demoralize the movements of an animal, as cutting *all* the sensory nerves does.

Alrutz reported some observations on the temperature sense. He is able to evoke a sensation of cold by stimulating the cold spots with warm objects (under certain conditions). The sensation of heat or burning, as distinguished from that of simple warmth, is, he believes, produced by the simultaneous stimulation of both hot spots and cold spots.

Mlle. Joteyko made it probable that the nerve centers are much more resistant to fatigue than the peripheral motor organs.

Schuyten reported, from the pedological bureau of the city of Antwerp (a unique institution), a series of tests of the muscular strength (grip) of pupils throughout the school year. In order to eliminate the effects of increase in age, he ascertained the age in months of each child, and tested him only in the month when he had a certain age, viz, 8 years 9 months in one series, 9 years 9 months in another. The results for the two series, and for girls and boys, showed a close parallelism. There was a gradual increase in strength from October to January, a fall from January to March and a rise again to June or July. March was the weakest month, June and July the strongest.

Netchaeff, of St. Petersburg, reported on some tests of the memory of school children for various sorts of impressions: objects seen, objects heard, names recalling visual, auditory or tactile impressions, names of emotions, abstract names and numbers. He found the memory to be best for objects seen, and next best for names of visual impressions; it was poorest, up to the age of 12 or 14, for names of emotions, and beyond that age for numbers and abstract names. The memory for numbers was always about as strong as for abstract names; and the increase in power to remember these two was, from 9 to 18 years of age, rather slight. The increase was greatest in case of objects seen and of words denoting emotions. The rapidity of the growth of memory fell off at puberty. The boys excelled the girls in remembering objects, the girls excelled in remembering names and numbers.

Psychical research was thoroughly ventilated at the Congress. Flournoy presented his observations on the celebrated medium Helen Smith. Myers and others testified to the remarkable revelations made by Mrs. Thompson—who, by the way, was present at the meetings, and certainly did not give one the impression of anything abnormal or uncanny. Encausse described some electrical apparatus for automatically recording the movements of mediums during a trance, so that their movements may be known, without the embarrassing presence of a scientific observer. Baraduc and others expounded queer ideas and demonstrated queerer-seeming facts relating to 'psychic exteriorization,' etc. Finally, a new psychical research society, the *Institut Psychique*, designed to have an international following, was inaugurated.

No great amount of new apparatus was exhibited at the Congress. Sommer presented some ingenious instruments for recording movements in three dimensions of the hand or leg, also for measuring the size of the pupil in reactions to light, emotions, etc. Scripture exhibited some of his color demonstration apparatus. In addition to this, Binet showed us his laboratory at the Sorbonne, equipped largely for the registration of movements, pulse changes, etc.; and Toulouse invited us out to the Asylum at Villejiuf, where he has installed a psychological laboratory equipped with several new forms of apparatus for testing sensations.

All the Parisian psychologists, in fact, were extremely hospitable. The visitors had every opportunity to meet them and each other, and the sociability of the Congress was one of its most successful features.

R. S. Woodworth.

SCIENTIFIC BOOKS.

Éléments de paléobotanique. By R. Zeiller. Paris, 1900. Carré et Naud. 8vo. Pp. 417. Illustrated.

The remarkable increase in accessions to our knowledge of fossil plants, which has taken place within the last two decades, coupled with a similar advance in our knowledge of existing species, and a recognition that a proper correla-

tion of these two lines of botanical study must have an important bearing upon our knowledge of phylogenetic relations, has led botanists to look forward with confidence to the issue of works which would bring paleobotanical research into harmony with botanical knowledge in other directions, and serve to definitely eliminate the many errors and misconceptions consequent upon a copious but scattered literature, much of which had its origin at the hands of investigators who, although well qualified for their task in other respects, nevertheless lacked the essential element of special training and insight as botanists. In his 'Fossil Botany' issued in German in 1887, and reissued in an English edition in 1891, Solms-Laubach first opened the way to this reform, but his admirable work left much ground untouched. The expectations of botanists were more fully and most agreeably met by the issue of the first volume of Seward's 'Fossil Plants' in 1898, a work in thorough accord with the most recent views of botanical relationship and plant development, and which also possesses, among other excellent features, the great merit of having issued from the pen of one who is not only a thoroughly trained botanist, but one who has likewise acquired an intimate knowledge of geological facts. Before the completion of this epoch-making book, we are called upon to welcome another less pretentious, but nevertheless excellent work at the hands of a French author of wide repute. The extended experience as a paleontologist which M. Zeiller has enjoyed for many years, and the great excellence of his well-known publications on fossil plants, will serve to make this latest contribution from his pen a particularly welcome one to botanists.

The 'Éléments de paléobotanique' follows somewhat the same general scheme as Seward's 'Fossil Plants,' but it is much less complete in detail. The plan of treatment embraces a consideration of

1. The mode of preservation of fossil plants.
2. Classification and nomenclature.
3. A systematic treatment of the various groups of plants, commencing with the Thallophytes.
4. The succession of floras and relation to climatic conditions.
5. General considerations bearing upon the evolution of plant forms as indicated by the evi dence of fossil plants.

The chapter on classification is devoted chiefly to general considerations and leaves much to be desired in the way of defining the author's position with respect to the relations of the various groups of plants. This is, however, the natural result of approaching the subject from the standpoint of the experienced geologist, rather than from that of the expert botanist, and a clearer conception of his point of view is gained from the subsequent section on a systematic treatment of the various groups, wherein he adopts a plan which, in some respects, can hardly be regarded as in accord with the most recent views of plant relationship. Such defects in systematic treatment, however, are of minor importance and are readily overlooked in considering the excellence of the material which he presents and which in many cases also has the added merit of freshness, practically extending the ground covered by Seward's types.

In the systematic section, the treatment of the algæ is brief, and hardly serves to convey an adequate idea of the extent to which the most delicate and perishable of all the plants found in a fossil state are preserved. A concise statement presents the leading facts relating to *Nematophycus* so far as published results are known—a plant which, while appropriately considered under forms of doubtful or uncertain relationship, is probably to be regarded as representing a generalized type which may eventually be found to include representatives of both the Siphonæ and Laminarieæ, although recently acquired evidence would seem to point to the latter in most cases. The Characeæ is dismissed with a short paragraph which, in spite of the relatively unimportant position which this group occupies among fossil plants, fails to convey an adequate idea of our knowledge concerning them, and entirely ignores their probable occurrence in paleozoic time. The fungi are briefly considered, and they are made to include the myxomycetes, the occurrence of which is very problematical, and the bacteria, of which two excellent illustrations are given—one of *Bacillus vorax* and one of *Micrococcus guignardi*.

The Bryophytes are dismissed with a short chapter which is in harmony with the fact that they constitute one of the least-known groups among fossil plants.

Attention appears to have been concentrated chiefly upon the vascular plants, of which the author presents a well-chosen selection of types and among which he seems well at home. The most noteworthy feature of this section of the work, and one which gives it special prominence in advance of previous publications, is the recognition for the first time, of the recently established Cycadofilicinæ which marks the most important advance in paleobotany within recent years, and at once indicates the nature of the data which a further study of fossil plants may be expected to contribute to our knowledge of the evolution of plant life.

The value of the book is greatly enhanced for the purposes of the working botanist or the student, by the superior character of the illustrations. Taken either by itself or in connection with Seward's more elaborate work, which it largely supplements, it affords a hand book of considerable utility.

D. P. Penhallow.

Montreal, Sept., 1900.

La spéléologie, ou science des cavernes. Par E. A. Martel. I volume, 8 vo., pp. 126, avec 10 figures. Prix 2 francs. Collection Scientia Série Biologique, No. 8. (Georges Carré et C. Naud, Editeurs, 3, rue Racine, Paris.)

A series of small volumes is being issued under the direction of MM. Milne-Edwards, Gaudry, Filhol, Balbiani, and other members of the Institute of France; one of the most recent of them being a hand-book on caverns and their contents. Its title, 'La spéléologie,' is coined from two Greek words, and means the Science of Caverns. This term is an improvement on the German 'Hœhlenkunde,' long in use in Austria, for the reason that the latter does not recognize the scientific claim on which emphasis is now laid; 'kunde' being the synonym of intelligence, or news, rather than of a classified knowledge. La Société de Spéléologie, of which M. Emilé Riviere is now president, and M. Edouard A. Martel the general secretary, is in the sixth year of its existence, numbers many eminent scientists among its members, with its headquarters at No. 7 rue des Grands-Augustins, Paris, whence it issues a regular bulletin telling the latest news from all parts of the known subterranean world, and publishing special contributions of scientific value. Important service has thus been done to geologists, archeologists, zoologists, hydrologists, mining engineers and hygienists. M. Martel has for many years devoted his summers to the exploration of caves in France, Spain, Greece, Switzerland, Austria, Belgium, Great Britain and elsewhere; and no man is better qualified than he to treat of the Science of Caverns, as he has so successfully done in the work under consideration.

'La spéléologie' is divided into sixteen chapters. The first chapter defines terms, corrects certain errors and prejudices, traces the history of under-ground exploration, gives a succinct bibliography of cave literature for a century, and indicates the many ways in which this branch of study has aided mankind. The second chapter deals with the causes producing caverns; which are mainly, first, pre-existing fissures in the rocks, due to earthquakes, volcanic eruptions, and other means by which the earth's crust has been rent asunder; and secondly, rain-water, charged with acids from the atmosphere and the soil, which seeks the fractures, faults and diaclases thus made, and enlarges them by erosion, corrosion, and hydrostatic pressure. This triple process is more fully explained in several successive chapters. Corrosion is exemplified by the destruction of gypsum and rock salt, and other soluble formations. Evidences of erosion abound in marine grottoes and volcanic caves. Columns of water weighing many atmospheres often stand in deep pits, or flow through secret conduits, bringing tremendous pressure upon the rocky strata before which they must yield.

The author deplores the prevalent confusion of nomenclature employed to describe the phenomena and results of aqueous agency. On pages 32 and 33 he spreads before the reader an elaborate table of the names by which pits, chasms, and other exterior and interior openings are designated in different countries of Europe and America; also offering suggestions as to unification or simplification of terms.

Ordinarily corrosion, erosion and hydrostatic pressure work simultaneously in cave-making. The acids eat into the softer portions of rock, leaving the harder parts as gravel, or sand, which the whirling or flowing water uses to grind a channel for drainage to an outlet.

M. Martel finds limited subterranean reservoirs, and also sheets of water held by saturation in mellow soils and porous strata, but denies the existence of vast bodies of water ('nappes d'eau'), such as are insisted on by certain ancient and modern authorities—even as recently as 1897—in order to explain the phenomena of artesian wells. He describes the sinking and resurgence of streams; and also a system of siphonage, which, as he remarks, belongs to hydrology rather than to speleology. Certain caves, however, are really but the channels of underground rivers whose waters have found some other bed.

The chapter on 'Abimes,' or natural pits, is peculiarly interesting, although, as the author admits, their origin has been an occasion of 'interminable controversy.' We cannot now follow him through his elaborate discussion of the theories of glacial grinding, of geyser chimneys, of interior excavation, the 'théorie du jalonnement' (*i. e.*, that they are drainage outlets for ancient lakes), and other theories. For this and much other interesting material the reader is referred to Martel's great work, 'Les abimes,' pp. 576, Paris, 1894. The theory finds favor that the abimes are generally due to exterior causes, working downward from the surface, rather than to interior forces. This is especially evident in the 'avens' that pierce the vast limestone plateaus, known as 'causses'—a term derived from the Latin 'calx.' Some of these avens drop vertically for from 200 to 700 feet, and then expand into vast chambers, occasionally with bodies of water, but often ending in numerous fissures of drainage.

M. Martel gives a list of abimes actually measured and known to be more than 200 meters in depth. The deepest of all is a perilous pit named in honor of its discoverer, M. David Martin, and located near Saint Disdier, amid the Hautes Alpes, at a point about 5,000 feet above the sea. Martel descended more than 1,000 feet vertically, and estimated the entire depth at about 1,600 feet. The writer of this review had the satisfaction personally, in 1897, of witnessing Martel's exploration of the Aven Armand, in Lozére, a pit more than 600 feet deep. The rope ladders, portable telephones and other apparatus made a striking display. In other pits that were intersected by streams a curious plan was taken for tracing the waters by discoloration by flourescein.

After describing stalactites, stalagmites and other forms of drip-stone, whose tendency is to obliterate caverns, and whose rate of growth has been recorded as indicating the age of the excavations in which they exist, M. Martel states the difficulties of the problem fairly, and concludes that it is impossible to affirm, in the actual state of our knowledge concerning subterranean channels, just when they began to exist; but he suggests the middle of the Tertiary epoch.

Particular attention is paid to the temperature of caverns, the purity or impurity of cave atmosphere, and the contamination of springs and subterranean reservoirs in relation to the public health. Natural ice-houses, and the theories of their formation, furnish material for an interesting chapter. Four causes are assigned, namely, the shape of the cavities, free access of snow in winter, altitude, and evaporation by currents of air. In this connection researches and adventures amid Alpine snow-pits are described. Cavern minerals are diversified. Among those mentioned are the various metallic ores, clays, carbonates, phosphates, and salts. Brilliant colors are often given to stalactites by copper and other metals.

Recent prehistoric explorations have been richly rewarded by relics found in cliff-dwellings and subterranean temples. Still more ancient are the remains of the paleolithic, neolithic and bronze ages. Many of the most noted of the inhabited caves and grottoes are mentioned by name. Living troglodytes are described, and also underground cemeteries, from which hundreds of human skeletons have been exhumed. Discoveries in the United States are by no means overlooked, particular mention being made of those in Pennsylvania, Indiana, Kentucky and Tennessee.

Subterranean fauna and flora, their origin,

habitats, and the modification of their organs by adaptation to environment, fill the concluding chapter of this remarkable little volume. Directions are given for hunting cave animals and observing their habits. Authorities are conscientiously and carefully quoted, with fewer mistakes than might have been anticipated in a work of this comprehensive nature, and with evident intention to give due credit to investigators on both sides of the Atlantic.* In conclusion, we accept M. Martel's handbook as an admirable and timely contribution to current scientific literature.

Horace C. Hovey.

The Criminal: His Personnel and Environment. A Scientific Study. By August Drähms, with an introduction by C. Lombroso. New York, The Macmillan Co. 1900. 8vo. Pp. 402.

In a brief introduction to this book Professor Lombroso congratulates the author on his 'lucid exposition' and 'profound and original thought,' stating, further, that he has seldom met with so clear an exposition of his own views. This testimonial is not altogether calculated to carry weight, for even those who acknowledge a discriminating admiration for Lombroso's genius are well aware that a sound critical faculty is not one of the elements of that genius. It is possible that even the author himself may have been surprised at the excess of this appreciation; for Mr. Drähms is by no means so much in sympathy with Lombroso, as Lombroso is with Mr. Drähms. In his preface the latter states that "the strictly anthropological features here brought out have been accepted mainly as the properly accredited data of trained writers, the latchets of whose shoes I am not worthy to unloose, but whose conclusions nevertheless are taken under a general demurrer; in which respect, however, I have the consolation of knowing that I am in excellent company." Any one who carefully studies this statement will know how far this book is likely to prove useful to him; in its vague phraseology and its non-committal deference to people of all views, it is characteristic of the author's attitude throughout. He attempts to cover the whole field of criminal anthropology and criminal sociology. But not only do the original facts he has brought forward scarcely occupy a couple of pages; his acquaintance with the facts brought forward by others is nearly all second-hand, derived from sources already easily accessible in English, nor is any reference made to even the more important investigations of recent years, such as Winkler's attempt to deal with the data of criminal anthropology on a mathematical basis, or Steinmetz's studies of the evolution of punishment. He loosely discusses views to which he never gives precision by definite citation of authorities, and when he mentions authorities he is unable in a large proportion of cases even to spell their names. It is not impossible for a prison chaplain to do good work in this field, as Mr. W. D. Morrison has shown in England. But Mr. Drähms reveals no signs of that clear vision and intellectual grip which enable a man to conquer defects of scientific training. He takes a sane common-sense view of things, and as regards the treatment of criminals this leads him sometimes even to an advanced position, as when he advocates an unrestricted indeterminate sentence. But the possession of average sanity and common-sense is an inadequate equipment in writing a book which is prominently announced as 'a scientific study.'

It is necessary to state this clearly even at the risk of hurting the feelings of an amiable and well-intentioned writer. In the more abstract sciences there is no temptation to careless work; but in the anthropological and psychological sciences there is a temptation, even for an honest writer, to mask his scientific ineffectiveness under the human interest of his subject matter. In so far as he succeeds he discredits the science with which he occupies himself. The study of the criminal has suffered severely from this cause, and a book on

* On page 114 M. Martel inadvertently attributes to another my discovery of the prehistoric quarries of jasper and alabaster in Wyandot Cave, Indiana. My exploration was originally made in 1855, and my account of the quarries was published in the *Am. Jour. of Science and Art*, in 1878; whereas the account quoted from the *Proceedings* of the American Phil. Society did not appear till 1895.

this subject which proclaims itself as 'scientific' must expect severe scrutiny.

Mr. Drähms would have been well advised, and would have served better the cause of science, had he been content (like some French prison chaplains) to set down a brief and simple record of those things which during his residence in San Quentin he has himself seen and known.

HAVELOCK ELLIS.

BOOKS RECEIVED.

Physiology for the Laboratory. B. M. BROWN. Boston, Ginn & Co. 1900. Pp. viii + 167.

Laboratory Directions for Beginners in Bacteriology. VERANUS A. MOORE. Boston, Ginn & Co. 1900. 2d edition. Pp. xvi + 143.

SCIENTIFIC JOURNALS AND ARTICLES.

THE current issue of the *American Anthropologist*, Vol. II, No. 3, July–September, 1900, is of unusual interest, almost the entire field of anthropology being covered by the ten articles which comprise the principal part of its 200 pages. In his paper on 'Obsidian Mines of Hidalgo, Mexico,' Professor W. H. Holmes, of the National Museum, describes the process employed by the natives in obtaining obsidian during the centuries necessary to produce the flakage so thickly covering hundreds of acres on the mountain slopes, one heap alone being estimated to contain twenty or thirty thousand cubic feet of this artificially flaked material. The process of flaking is also described and illustrated. A complementary article, 'The Obsidian Razor of the Aztecs,' by Dr. George Grant MacCurdy, of Yale University, describes and explains the distinguishing features of obsidian fracture, and shows that to them is due, in a measure at least, the excellence of obsidian as a material for knife and razor making. Early last spring Dr. J. Walter Fewkes, of the Bureau of American Ethnology, made an examination of some remarkable but little-known cavate and pueblo ruins (the latter still standing several feet in height), northeast of Flagstaff, Arizona, and he also conducted some excavations therein. The results of these observations are now exploited (with several excellent views and ground-plan drawings) under the title 'Pueblo Ruins near Flagstaff, Arizona.' Judging from the character of the houses, the pottery and other art products, and his knowledge of the traditions of the Hopi Indians, the author is inclined to attribute these now-ruined pueblos to that tribe. An excellent article by Mrs. Alice Carter Cook is devoted to 'The Aborigines of the Canary Islands,' based on information obtained from personal observation in the archipelago and intimate acquaintance with the early Spanish literature of the subject. Every phase of the life of the people is described, and type pictures of the inhabitants and their curious dwellings are given. Still another corner of the world is treated in Mr. R. H. Mathews' paper on 'The Wombya Organization of the Australian Aborigines,' in which various unusual customs are also set forth. Dr. Swan M. Burnett presents a scholarly essay on 'Giuseppe Mazzini—Idealist: A Chapter in the Evolution of Social Science,' in which is given some portions of the great reformer's labors, with the underlying principles for which he contended with such courage and persistency as have rarely been equalled in the history of human endeavor. A 'Grammatic Sketch of the Catawba Language' of South Carolina is given by Dr. A. S. Gatschet. This almost extinct tongue belongs to the Siouan stock, and but few examples of it have ever been published. Mr. Gerard Fowke, whose wide experience in archeologic investigation of the Mississippi drainage area, and his familiarity with the supposed Norse remains in Massachusetts (first discovered and described by the late Professor E. W. Horsford, and later by his daughter, Miss Cornelia Horsford) make his study of the 'Points of Difference between Norse Remains and Indian Works most closely resembling them' of double interest. Mr. Harlan I. Smith, of the American Museum of Natural History, presents the details of his 'Archeological Investigations on the North Pacific Coast in 1899,' conducted under the auspices of the Jesup Expedition, and H. Newell Wardle discusses the interesting 'Sedna Cycle' of the Eskimo which sheds new light on the mythology of the most northerly inhabitants of the globe. The usual 'Book Reviews,' discussion of 'Periodical Literature,' and 'Notes and News' complete the number. (G. P. Putnam's Sons, Publishers, New York.)

But two articles of the October *Monist* are technically scientific in character. The first is by Professor A. S. Packard, of Brown University, and gives for the first time, in actual translations, a complete statement of Lamarck's views on the origin and evolution of man, and of his thoughts on morals, and on the relation between science and religion. Professor Packard believes that Lamarck's attempt at explaining the probable origin of man from some arboreal creature allied to the apes is more detailed and comprehensive than that offered by Darwin in his 'Descent of Man,' which was virtually anticipated by Lamarck. The second article, by Professor Arnold Emch, of the University of Colorado, treats of the 'Mathematical Principles of Esthetic Forms.' Starting from the physiological conditions for the perception of esthetic forms, the author proceeds to investigate the abstract law of symmetry as embodied in the principle of the group, projective and perspective transformation, inversion, etc., showing, for example, that the principle of repetition finds its mathematical expression in the geometry of the group, and explaining also why the various species of geometrical transformation do not destroy the impressions of axial and central symmetry. The remaining articles are: (1) an essay on modern Biblical criticism, by Professor Paul Schwartzkopff, entitled 'The Belief in the Resurrection of Jesus and its Permanent Significance'; (2) an illustrated paper on the 'Greek Mysteries as a Preparation for Christianity,' by Dr. Paul Carus; (3) 'The Ethics of Child-Study,' by Dr. Maximilian P. E. Groszmann; and (4) a report on the recent Psychological Congress at Paris. (Chicago: The Open Court Publishing Co.)

The Journal of Physical Chemistry, October. 'Toxic Action of Acid Sodium Salts on *Lupinus albus*,' by Louis Kahlenberg and Rollan M. Austin. Acid salts are found to be much more poisonous than they ought to be, assuming their toxicity to be due to the hydrogen ions only. 'Relationships between Thermodynamic Fundamental Functions,' by J. E. Trevor. 'The Boiling-points of Mixtures of Chloral and Water,' by Joseph C. Christensen. 'On the Emission and Absorption of Water Vapor by Colloidal Matter': correction, by P. Duhem. 'Quantitative Lecture Experiments on Electro-Chemistry,' by W. Lash Miller and Frank B. Kenrick. Description of an ingenious measuring instrument for rendering the results of experiments visible to a large audience, and a number of selected experiments.

SOCIETIES AND ACADEMIES.

NEW YORK ACADEMY OF SCIENCES.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

A meeting of the Section was held on Monday, October 1st, at 12 West 31st Street.

Professor E. R. Von Nardroff presented a paper 'On the Application of Fizeau's Method to the Determination of the Velocity of Sound,' with an experimental illustration. He used sound of very short wave length, beyond the limits of hearing. The sound was detected by means of a sensitive flame. He overcame the effect of irregular disturbing reflected and diffracted waves by using sound of considerable intensity and a flame only slightly sensitive. The sound after passing between the teeth of a rapidly revolving wheel, fell on a concave spherical mirror made of wood, some distance away, and was reflected back through the teeth at the opposite end of a diameter of the wheel, and came to a focus on a sensitive flame just behind the wheel. The author gave a neat demonstration of the working of the apparatus, and showed with great ease how with increasing speed of the revolving wheel the flame was alternately shielded from and exposed to the sound. The slightest disturbance of the adjustment of the mirror threw the focus away from the flame in a marked manner. He stated that the method could probably not be used to compete with other accurate methods heretofore used, but it supplied a beautiful illustration of Fizeau's method of measuring the velocity of light.

Professor J. K. Rees gave an interesting account of some of the scientific instruments at the Paris Exhibition. The great telescope was not yet finished, although this fact was not yet generally known, and it was impossible to tell yet whether it was to be a success. The German exhibit was superb. The Germans had a

method which ought to have been generally adopted, of arranging the instruments with each kind by the different makers in one case, instead of a complete line by each maker in a case by itself. An ingenious modification of Foucault's pendulum was seen at the Paris Observatory. It was only one meter long, but it showed the fact of the rotation of the earth after the lapse of fifteen seconds.

Professor Hallock described a peculiar lightning discharge he had observed at Lake Champlain. The flash came unexpectedly from a cloud about two miles from where the main shower was falling. It struck on a mass of rock, and on examining this it was found that instead of there being one or a few places where the lightning had struck, it was covered with innumerable little spots, each one indicating where a part of the flash had struck.

WILLIAM S. DAY,
Secretary.

NOTES ON PHYSICS.

THE GALTON WHISTLE.

IN the *Annalen der Physik* for July, 1900, Edelmann describes an improved form of the Galton whistle for use in studying the limits of audibility of high pitch sounds. This improved form of whistle is similar to the locomotive whistle in design, the vibrating air column being from 2 to 4 millimeters in diameter and from 0.7 to 5 or more millimeters in length. With a whistle 2 mm. in diameter Edelmann has produced sound waves, using the word sound in its physical sense, of 2 mm. wave-length, corresponding to a vibration frequency of 170,000 double vibrations per second. This is nearly an octave higher than the highest pitch obtained by König in 1899.

Edelmann determined the pitch by measuring the wave-length of the sound as indicated by Kundt's dust figures, in an elongated glass tube resonator. This resonator for the very high pitch waves was less than a millimeter in diameter of bore and about ten millimeters in length.

The present writer remembers well a very striking lecture experiment by Professor Kundt in 1890, in which the pitch limit of audibility was demonstrated by a Galton whistle, the actual existence of the physical sound, when the whistle was adjusted to give more than about 40,000 vibrations per second, was beautifully shown to a large audience by the effect of the whistle upon a sensitive gas flame.

THE GENESIS OF THE IONS IN THE DISCHARGE OF ELECTRICITY THROUGH GASES.

THE phenomena of the electric discharge through gases seemed only a few years ago to be so complicated that physicists almost despaired of finding an hypothesis which might bring order out of the mass of experimental results which had accumulated.

The discovery of the Röntgen rays stimulated research in this field greatly, and the observation that these rays in passing through a gas cause it to become an electrical conductor soon gave fixedness to the idea that a gas conducts electricity by having its molecules broken up into positively and negatively charged parts or ions which wander about through the gas.

This ionic hypothesis has already been of great value in suggesting lines of research; and the rapidly accumulating results of these recent researches, interpreted, of course, through the ionic hypothesis itself, show, under the widest variety of conditions, a degree of consistency which is rapidly giving to the ionic hypothesis the dignity of an established theory.

Some of the most striking applications of the ionic hypothesis have been noted in SCIENCE during the past three years.

PROFESSOR J. J. THOMSON, in the *Philosophical Magazine* for September, points out in a paper entitled 'The genesis of the ions in the discharge of electricity, through gases,' why the dielectric strength of a gas is approximately proportional to the pressure of the gas; why the dielectric strength of a thin layer of gas is greater than the dielectric strength (volts per centimeter) of a thick layer of the same gas; and he explains the striations of the positive column or glow in a Geissler tube.

The reader should keep in mind that the scientific explanation of a thing is a description of the thing in the simplest possible terms. Many scientists feel an objection to the use of the word *explanation* in that its use tends to confirm a hearer in the acceptance of the figments of his

imagination not simply as a model of the world (for this is to some extent a practical necessity), but as the world itself. As Münsterberg puts it: The greatest danger of the present day in education is the confusion of boundaries between our logical constructions and the teleological realms. W. S. F.

SCIENTIFIC NOTES AND NEWS.

The National Academy of Sciences will hold its autumn meeting at Brown University on November 13th, 14th and 15th.

The American Society of Naturalists will meet at Baltimore on December 27th and 28th, and with it the affiliated societies devoted to natural history. Christmas day comes this year on Tuesday, and the balance of the week scarcely gives a suitable time for the meetings of those societies whose sessions last longer than two days.

It is reported that Sir John Murray, who is now engaged in an expedition to Christmas Island, will later join Professor Haeckel in Java. It will be remembered that the latter is searching for remains of *Pithecanthropus erectus*.

The Senate of New York University has received and confirmed the votes of its judges selecting thirty eminent native-born Americans whose names are to be inscribed in the 'Hall of Fame.' The Americans selected as the most eminent are distributed as follows: Rulers and statesmen, 7; authors, 4; inventors, 4; preachers and theologians, 3; judges and lawyers, 3; soldiers and sailors, 3; men of science, 2; philanthropists, 2; educators, 1; painters, 1. The inventors on this list are Fulton, Morse, Whitney and Howe, and the men of science Audubon and Gray. Franklin is of course also included. Ninety-seven judges voted and the votes cast for men of science were as follows: John James Audubon, 67; Asa Gray, 51; Joseph Henry, 44; Matthew Fontaine Maury, 20; Benjamin Thompson, 19; Benjamin Silliman, 16; Benjamin Peirce, 14; Nathaniel Bowditch, 10; Alexander B. Bache, 9; Spencer Baird, 8; Henry Draper, 8; Maria Mitchell, 7; David Rittenhouse, 6. Twenty further names are to be selected in 1902 by the same judges who may vote for those who received at least 10 votes in the present competition.

The death is announced of Dr. R. J. Kupper, formerly professor of geometry in the German Technical Institute of Prague.

The *Bulletin* of the American Mathematical Society states that the Steiner prizes of 6,000 Marks, which were not awarded, owing to no papers being presented, have been divided into three parts which have been given to Dr. Karl Friedrich Geiser, professor at the polytechnic school at Zurich, for his individual researches in geometry and his services in the publication of Steiner's lectures; to David Hilbert, professor in the University of Göttingen, for his important researches on the axioms of geometry and for the advancement which analytic geometry has experienced from his work on the theory of invariants, and to Dr. Ferdinand Lindemann, professor at the University of Munich who has earned special distinction in geometry by his celebrated discussion of the quadrature of the circle, as well as by editing Clebsch's 'Vorlesungen über Geometrie.'

The Hufeland Society, of Berlin, offers two prizes of 800 Marks for researches on the following subjects: (1) On the influence of salts in drinking water on the constitution of the blood and (2) The influence of thermal and mechanical stimuli on the circulation of the blood. The papers, which may be written in English, must be sent to Professor O. Liebreich, Neustadtische Kirsch Strasse 9, Berlin, prior to March 1, 1901.

A civil service examination will be held on November 20th for the position of assistant in serum therapeutics, Biochemic Division, Bureau of Animal Industry, Department of Agriculture. The salary of the position is $720 per annum, and the examination will be chiefly on serum therapeutics and elementary general chemistry.

No news has been received from the *Windward* later than August 10th, at which date, however, it had safely arrived at Godhaven, half way to Cape York.

It is reported that Mr. Ziegler of New York will defray the expenses of an expedition to the North Polar regions under the direction of Mr. E. P. Baldwin who accompanied Lieutenant Peary as meteorologist in 1893–94. The plan

is to have an elaborately equipped expedition with specialists in the different sciences and to start early next year.

THE medical works contained in the library of the late Dr. Alfred Stillé, of Philadelphia, have been bequeathed by him to the College of Physicians. The estate is left to relatives, but if they leave no heirs it also will go to the College of Physicians.

A LIBRARY known as the 'Seymour Technical Library' is to be established by friends of the late Major L. T. Seymour at Johannesberg, as a memorial to his services to the mining industry in South Africa.

THE appropriation made by the British government for the eight agricultural colleges of England and Wales is £7,750. These colleges have all been established within the past ten years.

THE new National Museum at Munich, containing the collection of Bavarian antiquities, has been opened, and the valuable collections can be viewed to much better advantage than hitherto. The building contains more than a hundred rooms and has been erected at a cost of about $1,000,000.

THE Authors' Catalogue of the British Museum, containing four hundred large volumes and numerous supplements, has now been completed. The compilation of the catalogue has occupied twenty years and cost $200,000. A subject-catalogue is now in course of preparation.

LORD LISTER gave the third Huxley lecture at the Charing Cross Medical School on October 2d, his subject being 'Recent Advances in Science and their bearing on Medicine and Surgery.' He described in some detail the physiological and pathological investigations that led to his great discovery. It will be remembered that these lectures before the Charing Cross Hospital Medical School were endowed as a memorial to Huxley, and are given once in two years. The previous lecturers have been Sir Michael Foster and Professor Virchow.

AT the Geographical Congress at Berlin in October, 1899, it was decided to form an International Seismological Society. The first meeting of the delegates will be held at Strassburg, April 11, 1901. The principal subjects chosen for discussion are: 'The organization and extension of investigation in different countries'; 'The selection of apparatus for international and local observations'; 'The annual publication of international reports,' and 'The status of the new society.'

THE attendance at the seventy-second annual meeting of German Men of Science and Physicians was about 1,100.

AT the Geodetic Congress which met at Paris at the end of last month, Sir David Gill, director of the Cape Town Observatory, reported the progress made in measuring an arc of meridian of 104 degrees from the Cape to Alexandria. They were passing by permission through German East Africa. Five degrees had been already measured in Rhodesia and three and a half in Natal. The measurement by international cooperation of an arc from French Congo to German East Africa was considered. A report was also made to the effect that the measurement of the geodetic line between Malta and Sicily had been successfully carried out under the superintendence of Dr. Guarducci, the chief of the geodetic division of the Italian Geographical Institute. The Malta station was at Gozo, and the chief Sicilian stations were on the mountains of Etna and Cammarata. The distance between Malta and Sicily is about 125 miles, and signals were exchanged at this distance by means of the oxy-acetylene search light.

THE *British Medical Journal* states that the Association des Anatomistes, which was founded last year, held its second meeting in Paris recently. The session was devoted to the discussion of business matters, the Association having for purposes of scientific work joined forces with the Section of Anatomy and of Histology and Embryology of the International Congress of Medicine. In the absence of Professor Mathias Duval, the chair was taken by Professor Henneguy, of the Collège de France. It was decided that the next meeting should be at Lyons in 1901, on Monday, Tuesday and Wednesday of the last week before Easter, un-

der the presidency of M. Renaut, with MM. Testut, Arloing and Ledouble as Vice-Presidents. Thirty-two new members were admitted, among them being Professors Waldeyer, His, Golgi, and Eternod. The Secretary of the Association is Professor Nicolas, Faculté de Médecine, Nancy.

UNIVERSITY AND EDUCATIONAL NEWS.

THE formal inauguration of Dr. Henry S. Pritchett as President of the Massachusetts Institute of Technology will take place on October 24th.

THE Trustees of Western Reserve University have voted to erect a new chemical laboratory for the work under the charge of Professor E. W. Morley.

MR. ALFRED L. JONES, of Liverpool, has offered £1,000 a year for five years towards a fund for establishing a comprehensive system of technical education in Wales.

A STUDENTS' observatory has lately been opened at Wellesley College, built and equipped by the enlightened liberality of one of the Trustees, Mrs. John C. Whitin. That the building is unusually beautiful, of white marble, with roof of ribbed copper, has not been allowed to detract from the equipment. A twelve-inch refractor of Alvan Clark & Sons, a three inch transit, a six-foot focus concave grating spectroscope and other necessary instruments are or soon will be in place. The dome by Warner & Swazey works easily, as it should in a woman's observatory, and is of graceful design, a hemisphere upon a cylinder. The address at the opening was by Professor E. C. Pickering. Greetings from Lady Huggins, Miss Agnes Clarke and Miss Dorothea Klumpke were read, and Professor David P. Todd spoke of 'Laboratory work in Astronomy.' Courses both in physical astronomy and mathematical astronomy are already initiated under the conduct of Professor S. F. Whiting and Professor Ellen Hayes.

THE annual commemoration exercises will be held at Princeton University on October 20th. The address this year will be by Bishop Satterlee, of Washington.

IT is reported that Dr. Adams will not again resume the duties of the presidency of the University of Wisconsin, but that Dr. E. A. Birge, professor of zoology and now acting president, will be installed as president.

PROFESSOR R. H. CHITTENDEN, director of the Sheffield Scientific School of Yale University and professor of physiological chemistry, has been made professor of physiology in the Yale Medical School.

J. W. FEELEY, M.S., professor of physics and geology at Wells College, Aurora, N. Y., has been appointed acting president in the place of Dr. W. E. Waters, who has resigned.

MR. HUGO DIEMER has been elected assistant professor of mechanical engineering at the Michigan State Agricultural College. He was formerly the head of the mechanical department of the Agricultural and Mechanical College at Greensborough, N. C.

PROFESSOR W. F. M. GOSS has been elected dean of the engineering school of Purdue University.

PROFESSOR ROBERTS LATTA, lecturer in logic and philosophy in the University of St. Andrews, has been appointed to the chair of moral philosophy in the University of Aberdeen, vacant by the transfer of Professor Sorley to the corresponding chair at Cambridge University.

LAWRENCE E. GRIFFIN, Ph.D. (Johns Hopkins University), has been appointed instructor in zoology in Western Reserve University.

J. B. FAUGHT has been appointed professor of mathematics in Michigan Northern Normal School at Marquette, Michigan.

RICHARD K. PIEZ, Pd.D. (New York University), has been appointed professor of psychology at the State Normal School, Oswego, N. Y. Dr. Piez assumed the duties of his chair upon his recent return from a special tour in Europe, in which he made a study of the applications of modern pedagogy in the actual work of continental schools. Pitt. P. Colgrove, Pd.D. (1900), has resumed his duties at the State Normal School, St. Cloud, Minn., after a leave of absence extending over two years, which he spent in study at the University. Dr. Colgrove will have charge of the departments of psychology and mathematics.